

THE OHIO JOURNAL OF SCIENCE

VOL. LVI

MAY, 1956

No. 3

A FAUNAL LIST OF THE CANTHARIDAE (COLEOPTERA) OF OHIO WITH DESCRIPTIONS OF NEW SPECIES

GEORGE WILLIAM MISKIMEN

Department of Zoology, Ohio University, Athens, Ohio

During the course of a taxonomic study of the family Cantharidae of southern Ohio certain information was found to be of general interest. Seventy-two species and one subspecies of Cantharidae have been found to occur in the state of Ohio of which 28 species and the single subspecies were previously recorded by other investigators. Forty-four species are new records for the state.

In the table below a single asterisk preceding the specific name indicates those species recorded previously. Species with two asterisks preceding are those representing new state records. Species listed without an asterisk are those whose distribution records elsewhere indicate the possibility of their occurrence in Ohio.

Chauliognathini

Chauliognathus:

**pennsylvanicus* Deg.

**marginatus* Fab.

Cantharini

Podabrus:

**rugosulus* Lec.

**tomentosus* (Say)

***appendiculatus* Fall

***frater* Lec.

frosti Fender

***brevicollis* Fall

***flavicollis* Lec.

nothoides Lec.

dreisbachi Green

**basilaris* (Say)

***punctulatus* Lec.

**protensus* Lec.

***fayi* Lec.

***brunnicollis* var. *brunnicollis* (Fab.)

brunnicollis var. *poricollis* Lec.

**iricostatus* (Say)

**pygmaeus* Green

***planulus* Green

diadema (Fab.)

***modestus* (Say)

***intrusus* Green

***puncticollis* (Kby.)

***cinctipennis* Lec.

***stehri* (Sp. Nov.)

***punctatus* Lec.

limbellus Lec.

simplex Couper

pattoni Lec.

Silis:

**percomis* (Say)

spatulata Lec.

**bidentatus* (Say)

***tatilibus* Blatch.

Polemius:

limbatus Lec.

***laticornis* (Say)

repandus Lec.

Cantharis:

- ***syvaticus* Green
- **excavatus* Lec.
- ***antennatus* Green
- ***walshi* Lec.
- **fraxini* Say
- ***tantillus* Lec.
- ***vilis* Lec.
- ***parvicollis* Green
- ***longulus* Lec.
- ***umbrinus* Green
- ***cartwrighti* Green
- **rectus* Melsh.
- ***cruralis* Lec.
- ***imbecillis* Lec.
- ***fenderi* (Sp. Nov.)
- ***nigriceps* Lec.
- greeni* Fall
- ***bilobatus* Mck-Fend.
- **carolinus* Fab

- ***hirticulus* Green
- **flavipes* Lec.
- mimeticus* Green
- ***nanulus* Lec.
- ***seiberti* (Sp. Nov.)
- ***cloughi* (Sp. Nov.)
- angulatus* Say
- **lineolus* Fab.
- ***luteicollis* Germ.
- **oriflavus* Lec.
- **scitulus* Say
- **bilineatus* Say
- ***neglectus* Fall
- **dentiger* Lec.
- ***rotundicollis* Say
- ***impressus* Lec.
- lecontei* Fall
- simpliunguis* Blatch.
- ***heterodoxus* Green

Ichthyurini

Tryptherus:

- **latipennis* (Germ)

Malthini

Malthinus:

- granicollis* Fend.
- **occipitalis* Lec.

- difficilis* Lec.

Malthodes:

- **similis* Fend.
- ***concavus* (Lec.)
- frisoni* McK-Fend.
- **parvulus* (Lec.)
- ***exilis* (Melsh.)
- ***wernerii* Fend.
- curvatus* Lec.
- **knilli* Fend.
- **mediocidens* Fend.

- chapini* Fend.
- spado* Lec.
- ***fragilis* Lec.
- **megapygus* Fend.
- arcifer* Lec.
- **canaliculatus* Fend.
- niger* Lec.
- ***fuliginosus* var. *fuliginosus* Lec.
- **fuliginosus* var. *flavicollis* Fend.

A number of new species were detected in collections examined and in field collections. Several of the more clear cut species are described below. Type specimens were collected by the author except as noted and are presently in his collection.

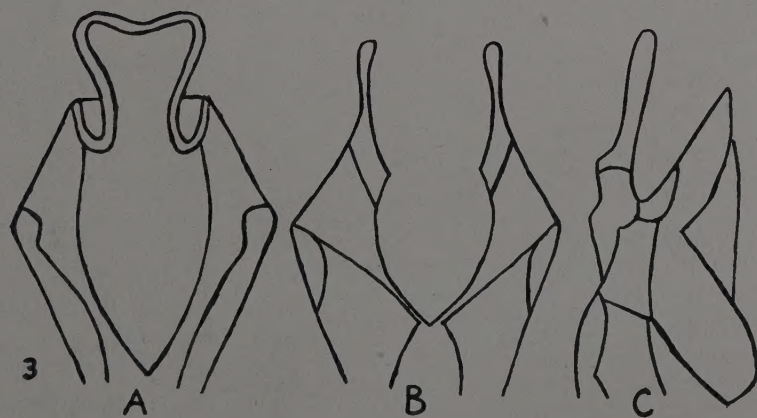
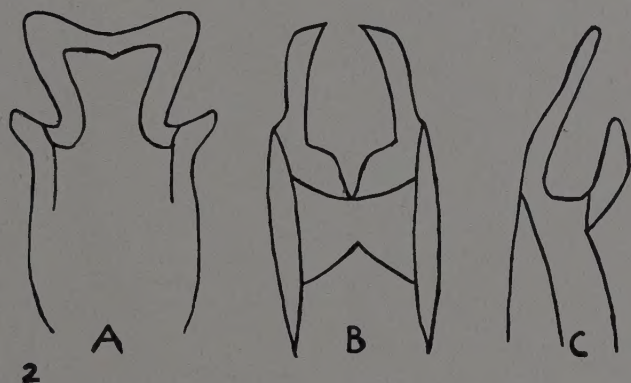
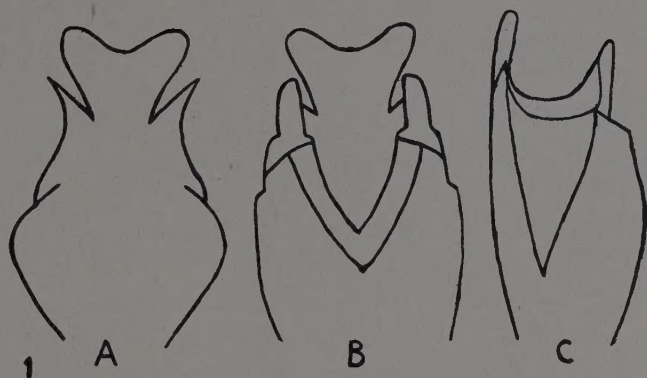
Cantharis fenderi sp. nov.

Color black; antennal bases and mouth parts pale; first two joints of antennae pale rufous, darker beneath; pronotum pale rufous with a median black vitta occupying the median one-

EXPLANATION OF FIGURES

DIAGRAMS OF GENITALIA

- FIGURE 1. *Cantharis fenderi* sp. nov.
- FIGURE 2. *Cantharis seiberti* sp. nov.
- FIGURE 3. *Cantharis cloughi* sp. nov.



third; elytra with pale lateral and sutural margins; body beneath piceous, gular region, prosternum, and median half of abdominal segments pale, distal and proximal femoral tips paler; tibiae and tarsi testaceous. Length 5.5 mm. (fig. 1)

Male: Eyes separated by one and two-fifths times their length; antennae four-fifths as long as the body, second joint two-thirds as long as the third, median joints three times as long as wide; clypeus feebly oblique on each side of the median notch; pronotum transverse, one and one-third times wider than long; elytral pubescence sparse; claws cleft with a stout blunt tooth shorter than the apical part.

Female: Not known.

This species keys out near *C. imbecillis* (LeConte) in Green's key of 1940. It may be differentiated by genitalic structure, pale posterior median half of each abdominal sternite, by dark legs including coxae, and by smaller eyes.

This species is named after Kenneth M. Fender of McMinnville, Oregon, who has contributed much to the study of the Cantharidae and who has given a great deal of aid to the author in his work with the group.

Type Locality: The Holotype was taken in net sweepings on goldenrod near Adams Mills, Muskingum County, Ohio on 10-VI-54.

Cantharis seiberti sp. nov.

Brunneous, head flavous anterior to the middle of the eyes; antennae brown, first two joints and base of third flavous, following joints very slightly pale at their bases; pronotum yellow with a brunneous median vitta which fails to reach the base or apex, vitta expanding anteriorly to form a transverse maculation occupying the median one-half of the pronotum; scutellum dark; elytra with pale lateral and sutural margins; gular region flavous, darkening in the genal area; prosternum, legs, and coxae flavous. Length 4.75 mm. (fig. 2)

Male: Eyes large and prominent, separated by one and one-fourth times their length; antennae three-fourths as long as the body, third joint one-fourth longer than the second, median joints four times as long as wide; clypeal apex sinuate; pronotum transverse, one-fourth wider than long, anterior two-thirds narrowed, almost impunctate, margins somewhat reflexed especially at the hind angles; elytral pubescence long and sparse; abdomen shining, pubescence prostrate; protarsal claws rather narrowly cleft, mesotarsal and metatarsal claws more widely cleft.

Female: Not known.

Closely allied to *C. mimeticus* (Green) and *C. nanulus* (LeConte). It may be distinguished from these on the basis of unlike genitalia, larger eyes than *nanulus*, shorter antennae than *mimeticus*, third antennal joint two-thirds as long as that of either of the similar species, median joints at least one-third wider, pronotum distinctly narrowed anteriorly, and an overall paler appearance.

This species is named in honor of Dr. Henri C. Seibert of Ohio University.

Type Locality: The Holotype was taken in clover sweepings near Cheshire, Gallia County, Ohio on 20-V-54.

Cantharis cloughi sp. nov.

Color black, ante-ocular area and antennal bases pale rufous, palpi rufous except for tips of terminal joints; first two joints of antennae pale rufous, first joint with dark area above, second joint darker distally, following joints dark piceous with bases paler; pronotum pale rufous with wide black vitta that expands somewhat at the anterior and posterior margins and at the basal tumidities; elytra piceous; body beneath piceous, gular region and prosternum pale rufous, coxae black with distal tips pale, femora black with both ends pale, tibiae and tarsi testaceous with terminal joints somewhat darker. Length 5 mm. (fig. 3)

Male: Eyes very small, separated by two and one-half times their own length; antennae three fifths as long as the body, third joint twice as long as the second, median joints three and three-fourths times longer than wide; clypeal apex oblique on each side of the median notch; pronotum transverse, one and one-fifth times wider than long, protarsal claws cleft with remainder of claws appendiculate.

Female: Eye small, separated by two and one-half times their length; antennae one-half as long as the body, third joint two-thirds longer than the second, median joints three times longer than wide; clypeal apex feebly oblique on each side of the median notch; pronotum transverse, one and one-fourth times wider than long.

Related to *C. proximus* and *C. impar* (LeConte) both of which are found on the east coast of United States. Genitalia are quite unlike, both species having an indentation on the terminal end of the dorsal lobe and short lateral processes with rectilinear tips.

The species is named in honor of Mr. Merwyn S. Clough of Appleton High School, Appleton, Wisconsin, who first introduced the writer to science.

Type Locality: Holotype and Allotype both taken on 20-V-54 on brush sweepings in a moist wooded area near Sugar Grove, Hocking County, Ohio.

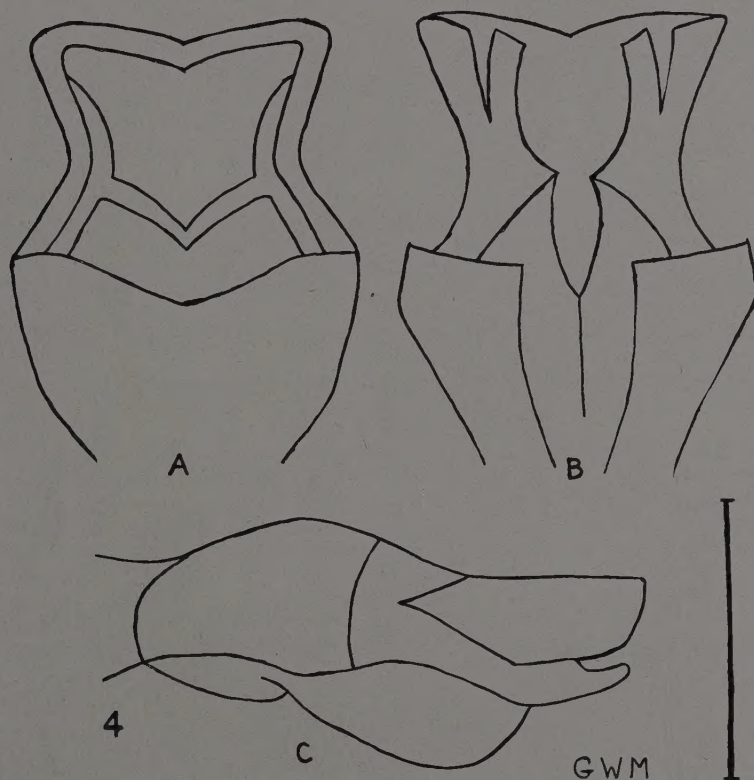


FIGURE 4. *Podabrus stehri* sp. nov.

A—Dorsal view

B—Ventral view

C—Lateral view

Solid black measured line equals 1 mm.

Podabrus stehri sp. nov.

Head dark rufo-testaceous posteriorly, flavous anterior to eyes including antennal prominences, sparsely punctate in flavous area, remainder of head densely and coarsely punctate; first two antennal joints flavous and sparsely pubescent, remainder of joints testaceous with dense pubescence; maxillary and labial palps flavous, terminal joints on each somewhat darker. Pronotum rufo-testaceous, one-third wider than long, lateral margins expanding slightly in front of the middle then narrowing to form obtuse anterior angles, hind angles slightly obtuse, basal and apical margins narrowly reflexed in basal half, densely punctate but less coarsely than the posterior half of the head, narrow impressed median line nearly reaching the base and much abbreviated in front; scutellum rufo-testaceous; elytra black with very narrow pale lateral margin expanding at the base. Underside of head rufo-testaceous, darker posteriorly, pronotum beneath flavous, rest of ventral surface piceous with lateral margins of sternites narrowly pale. Legs pale, tarsi slightly darker than other joints. Length 11-12 mm. (fig. 4)

Male: Head across eyes slightly wider than pronotum, eyes large, separated by one and one-half times their length, gular sutures parallel, narrowly but distinctly separated; antennae three-fourths as long as the body, second joint one-half as long as the third, median joints three times as long as wide; terminal joint of maxillary palpi subtriangular; elytra densely rugose, smoother basally, pubescence short and fine, nearly decumbent; legs slender, clothed with long decumbent pubescence, all claws with a broad basal tooth, the free angle of which is acute.

Female: Unknown.

Near *P. cinctipennis* (LeConte), an extremely rare species in North America, but differs in its genitalia, coloring of the anterior portion of the head and scutellum, smaller eyes, pale sutural margins of the elytra, and a narrower pronotum.

This species is named in honor of Dr. W. C. Stehr of Ohio University in recognition of his help and guidance.

Type Locality: Holotype 16-V-54, five paratypes 3-V-38, 20-V-54, 16-V-55, and 10-V-55 (2), taken at light in Athens, Athens County, Ohio.

The paratype specimen taken on 3-V-38 was collected by W. C. Stehr.

LITERATURE CITED

- Green, J. W. 1940. Taxonomic studies in *Cantharis*. Ent. Amer. 20: 159-222.
LeConte, J. L. 1851. Synopsis of the Lampyridae of temperate North America. Proc. Acad. Nat. Sci. Philadelphia 5: 342.
———. 1866. List of the Coleoptera of North America. Smithsonian Misc. Coll. 167: 91.
———. 1881. Synopsis of the Lampyridae of the United States. Trans. Amer. Ent. Soc. 9: 52-53.

Immunology and Serology. Phillip L. Carpenter. W. B. Saunders Company, Philadelphia. 1956. viii+351 pp. 51 figures. \$6.50.

This book consists of twelve chapters, an appendix of basic laboratory procedures or techniques in serology, and an index by subject and authors. Only one chapter is devoted entirely to infection and immunity. According to the author, "greater emphasis is placed upon serology than upon immunology, partly because more is known about it." Definitions or viewpoints, presumably the author's, on protection or immunity to infectious diseases, in which antibody becomes the major factor in all natural immunity, are probably equally responsible for this emphasis.

This concept of immunology is in contrast to the view that many biological, chemical and physical factors are involved in both native and acquired immunity, and in fact, many antigen-antibody phenomena are completely unrelated to immunity. Serious difficulty might be anticipated in the use of the book as a text in a course on immunology taught from this latter viewpoint. However, the various aspects of antigens and antibodies and their relationship to acquired immunity are adequately presented for students, "at the advanced undergraduate and early graduate level," for whom the book was intended by the author.

M. C. DODD.

REDESCRIPTION OF *ASPIDICHTHYS*: ARTHRODIRA, DEVONIAN

G. WINSTON SINCLAIR¹ AND DALE R. WALKER

Ohio Wesleyan University, Delaware, Ohio

In the early winter of 1952 the junior author, while searching for hibernating salamanders along Wieser Run, a small tributary entering the Olentangy River from the east some three miles south of Delaware, found a large arthrodire plate. This proved to be a median dorsal of *Aspidichthys clavatus*, and its discovery permits a better understanding of that poorly known species and genus.

Aspidichthys was established by Newberry (1873a, p. 322) for the single species *A. clavatus* Newberry (id., p. 322, pl. 35, fig. 1-2) and compared by him with "*Pterichthys*" *milleri*. No complete plate was known, and the description was based on an incomplete median dorsal which showed no diagnostic characters except a coarsely tuberculated surface. Reference of other species to the genus has of necessity been uncertain, and the systematic position of the genus itself has been indeterminate.

In describing a median ventral plate from the Devonian of Manitoba Whiteaves introduced the species *A. notabilis* (1892, p. 354, pl. 47, fig. 1, 1a). Whiteaves felt that this plate suggested relationship with the coccosteids rather than with the pterichthyids. Since then material from New York has been described and referred to Whiteaves' species: various ventral plates from the Genesee by Hussakof and Bryant (1918, p. 91-94) and a postorbital and antero-ventral median from the Ludlowville by Bryant (1929, p. 37).

Branson and Mehl (1931, p. 516) have described some fragmentary plates and a right antero-centro-lateral bearing a pectoral spine from the Jefferson formation of Utah. This material was referred to *Aspidichthys*, but without a specific designation.

In Europe the genus has been tentatively recognized in the species *A. ingens* v. Koenen, which has recently been redescribed by Gross (1933, p. 48; 1937, p. 40, text fig. 20).

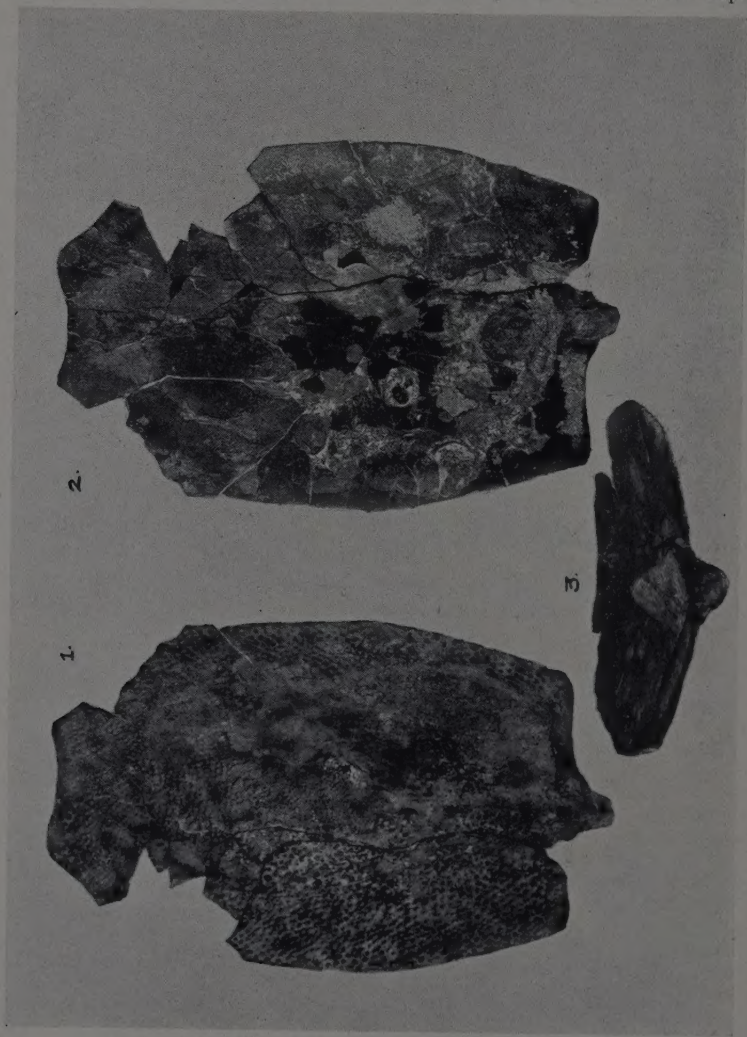
DESCRIPTION

The present plate is complete except for the antero-lateral corners and a small portion of the left posterior margin. It is large and subquadrate, with the antero-lateral corners truncated. The anterior margin is gently concave for about one-third of its width (for 90 mm.), then bends rather sharply to run directly or in a somewhat concave curve to the lateral corners (which are missing). The lateral margins are gently and irregularly convex, the postero-lateral corners sharp. The posterior margin is almost straight and transverse, apart from the posterior medial projection. The plate is rather evenly and moderately convex transversely, and almost flat longitudinally. The plate thins toward all the edges, which are well rounded in front and laterally, somewhat sharper at the posterior margin.

The posterior one-fourth of the dorsal side is marked by a prominent low rounded median ridge which is defined rather by depression of the postero-lateral corners of the plate than by any actual elevation of the median region itself. This ridge continues past the posterior margin of the plate, without change in contour, as a short projection. In lateral view this projection is sharply triangular, since its ventral surface is steeply inclined.

¹Present Address: Geological Survey of Canada, Department of Mines and Technical Surveys, Canada.

The ventral side of the plate is marked only by a prominent blunt rounded knob, which arises about 45 mm. in front of the posterior margin, a little to the left of the mid-line of the plate. The anterior slope of the knob is comparatively gentle, the posterior slope abrupt, and the lateral slopes intermediate in steepness.



DESCRIPTION OF PLATE

FIGURE 1 and 2. Dorsal and ventral views of the plate, $\times \frac{1}{4}$. The margins are entire except for the antero-lateral corners and a notch in the left posterior edge.

FIGURE 3. Posterior view, the anterior end of the plate slightly raised to show the ventral knob. The ventral surface is uppermost.

There is no trace of a keel, either in front of or behind the knob (*pace* Newberry). Two narrowly triangular depressed regions, very indefinitely delimited, may represent articular surfaces in contact with the anterior dorsolaterals. They extend to about mid-length, narrowing posteriorly.

The dorsal surface is covered with large scattered tubercles, averaging five to seven mm. in diameter, and separated by about the same distance. No pattern is seen in their distribution. Where perfect the whole surface, including the tubercles, is covered by a finely punctate surficial layer, which is readily lost. Where this layer is missing the tubercles appear smooth and shiny. In a few places the punctae on the lower slope of tubercles are sufficiently elongate to suggest radial grooves, but this is never a striking feature. The ventral surface is smooth, with a normal bony texture.

Dimensions. Length in the mid-line, 386 mm., greatest width (about one-third the length from the front), 257 mm., height as preserved, 42 mm.

Locality. The specimen was found in soft blue Olentangy shale along Wieser Run, and thus is from the type area and from approximately the type horizon of *A. clavatus*, for Newberry (1873 p. 157) emphasized that his specimen did not come from the concretions which carry most of the fossil fish at Delaware, but was found "lying in the laminated shale." The present specimen was in a horizontal position, the ventral side down.

Depository. The specimen is being placed in the U. S. National Museum, where it will bear the number 20730.

Remarks. The plate is impregnated with pyrite. Experiments on broken fragments suggested that chemical removal of the tough clay covering the specimen would be safe, but this proved to be wrong. The disfigurement of the right side of the dorsal surface is due to application of potash which caused local peeling. Other areas, apparently more thoroughly replaced, were unaffected. The critical region around the ventral knob is obscured by pyritic deposits, and further preparation was felt to be too hazardous to attempt.

Comparisons. Since no median dorsal plate has been described for the other American species direct comparison is not possible. It is plausible that *A. clavatus* and *A. notabilis* are congeneric. The median dorsal has been described in *A. ingens*, and differs rather strikingly in outline. The anterior outline is not recurved, and the posterior projection is very feebly developed.

Systematic position. This specimen confirms *Aspidichthys* as a good genus in the family Coccosteidae, differing in no essential way from better known genera of that family.

LITERATURE CITED

- Branson, E. B., and M. G. Mehl. 1931. Fishes of the Jefferson Formation of Utah. Jour. Geology 39: 509-531, 3pl.
Bryant, W. L. 1929. Fossil Fishes from the Hamilton Shales of New York. New York State Museum Bull. 28: 37-40, fig. 18-19.
Gross, W. 1933. Die Wirbeltiere des rheinischen Devons. Abhandlungen, Preussischen Geol. Landesanstalt, N. F. 154: 1-83, 11pl.
———. 1937. Idem, Teil II. Idem, Heft 176: 1-83, 10 pl.
Hussakof, L., and W. L. Bryant. 1918. Catalog of the fossil fishes in the Museum of the Buffalo Society of Natural Sciences. Bull. Buffalo Soc. Nat. Sci. 12: 1-346, 70 pl.
Newberry, J. S. 1873. Devonian System. Geol. Survey Ohio, Report, Vol. 1 (Geology and Palaeontology), Part I. Geology, p. 140-167.
———. 1873a. Descriptions of fossil fishes. Geol. Survey Ohio, Report, Vol. 1 Palaeontology, p. 245-355, pl. 24-40.
Whiteaves, J. F. 1892. The Fossils of the Devonian Rocks of the islands, shores or immediate vicinity of Lakes Manitoba and Winnipegosis. Geol. Survey Canada, Contributions to Canadian Palaeontology, Vol. 1, Part IV, p. 255-359, pl. 33-47.

PETROLOGY OF THE MASSILLON SANDSTONE AT THE TYPE LOCALITY

HENRY H. GRAY

Geologist, Indiana Geological Survey, Bloomington, Indiana

The Massillon sandstone, an arenite of commercial importance in northeastern Ohio, is a winnowed low-rank graywacke at its type locality, Massillon, Stark County, Ohio. High quartz content, medium granularity, and good sorting indicate a high-energy environment of deposition. Consistent north-northeast dip-direction of cross- and incline-beds suggests longshore currents as the agent of deposition and makes a southwestern source of the sediment probable. Petrographically similar Mississippian arenites may have been the source materials.

In the summer of 1951 the author began a general study of the Massillon sandstone of northeastern Ohio under the auspices of the Ohio Division of Geological Survey. The object of this investigation was the determination of stratigraphic relationships, areal extent, range in lithologic character, and origin of the Massillon sandstone. Early in this project observations were made and a suite of specimens was collected from the abandoned Warthorst or Everhard quarry of the Industrial Silica Corporation, located in NE $\frac{1}{4}$ NW $\frac{1}{4}$ section 7, Perry Township, Stark County, Ohio, in the outskirts of the town of Massillon. The rocks in

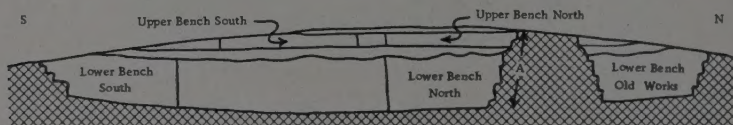


FIGURE 1. Profile of west wall of Warthorst quarry, not to scale. Length of diagram approximately 2,000 feet. Stratigraphic section was measured and lithologic samples were collected at locality A. Areas in which dip-directions of cross- and incline-beds were measured are labeled.

this quarry were designated by Newberry (1878, p. 166-167) as typical Massillon sandstone. A section measured in the north end of the newer workings shows 51 ft. of low-rank graywacke (defined by Krynine, 1948, table 3). When the quarry was in operation as much as 75 ft. of the rock was exposed, overlying the Number 1 (Sharon) coal and shale unconformably (Newberry, 1878, p. 166-167).

The quarry face consists of two benches. The lower bench, of which 30 ft. is exposed, is medium-grained quartzose graywacke. Above this lies 6 to 9 ft. of fine-grained graywacke interbedded with thin light-gray shale. The upper bench, which is as much as 12 ft. thick, is medium-grained quartzose graywacke. Glacial drift a few feet thick constitutes the overburden.

A stratigraphic section was measured by tape and hand-level and samples were collected in the north end of the newer workings (fig. 1). The units of subdivision used for description and sampling were sets of beds (defined by McKee and Weir, 1953), which are about the equivalent of "courses" of stone in quarrymen's nomenclature. Conspicuous horizontal or nearly horizontal parting surfaces separate the units. Composition, texture, and structure of each unit were described.

TABLE 1

Comparison of field and laboratory estimates of composition and texture. Units (sets of beds) are listed in ascending order. Lower bench, units 1-20; shaly break, units 21-30; upper bench, units 31-38.

Unit number	Thickness (feet)	Quartz content		Median grain size		Sorting coefficient
		Field est.	Thin section	Field estimate	Sieve analysis	Sieve analysis
1.	1.0	80%	—	Coarse	.4 mm.	1.1
2.	2.2	75	—	Medium-coarse	.38	1.2
3.	1.4	75	77%	Medium-coarse	.35	1.2
4.	0.7	75	—	Coarse	.36	1.3
5.	1.0	80	—	Medium-coarse	.35	1.2
6.	1.0	80	87	Medium-coarse	.28	1.2
7.	1.3	84	—	Medium-coarse	.38	1.2
8.	2.2	85	—	Medium	.31	1.2
9.	1.6	85	—	Medium-coarse	.36	1.2
10.	5.0	85	—	Medium-coarse	.31	1.2
11.	1.1	85	—	Medium-coarse	.33	1.1
12.	2.7	85	88	Medium-coarse	.30	1.2
13.	0.5	85	—	Medium-fine	.22	1.2
14.	1.4	85	—	Medium-coarse	.27	1.3
15.	0.6	85	86	Medium-fine	.21	1.3
16.	1.6	78	—	Medium-coarse	.28	1.2
17.	1.3	78	—	Medium-coarse	.26	1.2
18.	1.5	78	—	Medium	.28	1.2
19.	1.3	80	—	Medium-coarse	.29	1.1
20.	1.1	80	87	Medium-coarse	.26	1.2
21.	0.1	Shale	—	—	—	—
22.	0.4	80	—	Medium-coarse	.33	1.2
23.	0.4	85	—	Medium-coarse	.29	1.2
24.	1.7	85	88	Medium-coarse	.30	1.2
25.	1.3	75	—	Medium-fine	.17	1.4
26.	0.2	Shale	—	—	—	—
27.	1.4	75	—	Medium-fine	.14	1.6
28.	0.4	Covered	—	—	—	—
29.	0.8	80	73	Medium-fine	.13	1.8
30.	2.5	Covered	—	—	—	—
31.	2.9	85	—	Medium-coarse	.34	1.3
32.	1.6	85	—	Medium-coarse	.27	1.3
33.	2.0	82	—	Medium	.21	1.3
34.	0.5	82	—	Medium-coarse	.36	1.4
35.	1.9	82	—	Medium-coarse	.32	1.1
36.	0.6	82	88	Medium	.19	1.3
37.	0.6	82	—	Medium	.20	1.3
38.	1.5	82	—	Medium-coarse	.23	1.3
Total	51.3					
Weighted average		81.5%	85.0%	Medium-coarse (.46 mm.)	.29 mm.	1.2
Portion of thickness represented.		94%	19%	94%	94%	94%

PETROLOGY

Composition. Composition was estimated in the field by examination of hand specimens. Quartz grains make up most of the rock, (table 1), but considerable clay is present as coatings on the quartz grains, as matrix, and as detrital aggregates of about the same size as the grains. Selective staining of some of the clay by limonite gives a speckled appearance to the coarser graywackes. Muscovite, secondary quartz crystal overgrowths, and unidentified dark grains are present in small quantities and iron oxides are abundant locally.

Eight thin sections were analyzed under the petrographic microscope by the point-count method (Chayes, 1949). Six to eight traverses, totaling more than 1,100 individual points, were made across each slide. This allows 95 percent confidence limits of ± 2.5 percent for the major constituents. Quartz content ranges from 73 to 88 percent and averages about 85 percent (table 1). Of this, approximately 70 percent is individual quartz grains, 14 percent is aggregates (mostly quartzites with sutured contacts between the grains), and 1 percent is either very fine-grained quartzite or chert.

Clay content ranges from 11 to 26 percent and averages about 15 percent. Six clay types are recognized, but the distinctions between them are too slight to allow quantitative determination. These types include 1) fairly large (up to 0.1 mm.) flakes of sericite (?) that have medium relief and high birefringence and show no compactional disturbance; 2) finely crystalline, parallel-oriented aggregates of sericite (?) or illite (?) flakes that show slight iron-staining and some crushing due to compaction; 3) very finely crystalline, iron-stained, parallel-oriented aggregates of illite (?) or sericite (?) flakes that commonly are much distorted due to squeezing between the enclosing quartz grains; 4) amorphous (?) ferruginous clay masses that may be exceedingly fine-grained illitic or sericitic aggregates; 5) undisturbed aggregates of kaolinite (?) that have a mosaic pattern, low relief, very low birefringence, and undulatory extinction, and 6) clear, undisturbed, apparently amorphous aggregates which may be exceedingly fine-grained kaolinite mosaics. Type 3 appears to be most abundant.

Comparison of field and laboratory estimates of composition shows that minor constituents were consistently over-estimated in the field. Accessory minerals, such as muscovite and secondary quartz crystal overgrowths, were reported in quantities up to 2 percent in the field but were rarely seen in thin section. Field estimates seem fairly reliable for the major component, however (table 1); of the eight field estimates of quartz content which were checked microscopically, half fall within 5 percent and all fall within 10 percent of the value determined by point-count. A *t* test of the significance of the differences (Snedecor, 1946, p. 62-68) indicates that the mean difference, about 3 percent, is probably not significant ($t = 1.71$, $p = 0.14$). The *t* test allows an evaluation of the probability that two different groups of observations could have been drawn by chance from two larger groups (populations) that are not different.

Seven of eight field estimates showed lower quartz content than was measured in thin section. If the single over-estimate (unit 29) is disregarded, the mean difference between field and microscopic estimates becomes highly significant ($t = 4.45$, $P < 0.01$). It seems probable, therefore, that an over-estimate of less abundant constituents, notably clay, led to a rather consistent under-estimate of the quartz content.

Texture. Grain size was estimated in the field by comparison with standard samples (table 1). A spot-sample collected from each unit was analyzed by sieving. Disaggregation under water and preliminary wet-sieving reduced losses to less than 0.5 percent. Dry sieving of the $+0.062$ mm. portion of the sample was done with standard 8 inch sieves (Wentworth classes, 1 phi intervals) on a Cenco-Meiner machine with automatic timing (20 min. interval). The family of cumulative curves thus determined is represented in figure 2 by the limiting curves

and the mean of all curves. Comparison of the field estimate of grain size and the median size as determined by sieving shows a very consistent bias of 0.7 phi or about $\frac{3}{4}$ of a Wentworth class in favor of the coarser sizes. This bias probably is a result of overestimation of the quantity of the larger and more conspicuous grains, estimation based on the long axes rather than on the intermediate axes of inequidimensional grains, or both. A *t* test indicates a probability of less than 1 percent that this bias does not exist.

The median grain size of the graywackes ranges from 0.13 mm. to 0.40 mm. The mean of the medians, weighted for thickness of the unit represented by each, is 0.29 mm. Distribution of the medians about the mean approaches log-normal,

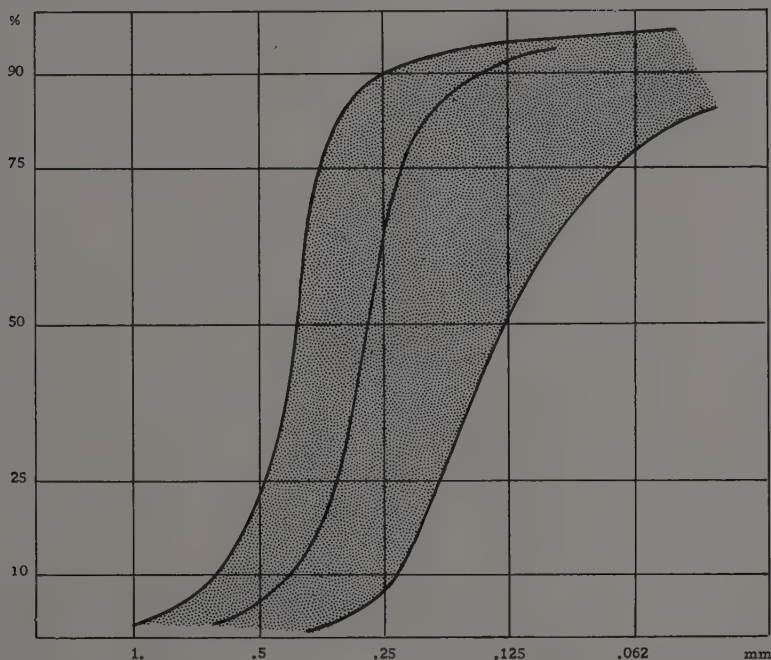


FIGURE 2. Limiting and mean cumulative curves in family of 34, Warthorst quarry, Massillon, Ohio.

but is skewed toward the fine sizes. Median size generally decreases from bottom to top of the quarry face, with local increases at the base of the upper bench and at the bottom of zones of cut-and-fill bedding such as units 16 and 22 (table 1). Grain size of the shales is not reported because shales are quantitatively insignificant and cannot be analyzed by a comparable technique.

Sorting coefficients (Trask, 1932, p. 71-72) range from 1.1 to 1.8. The mean is about 1.2, which indicates good sorting. Fine material is generally poorly sorted, but some of the coarser arenites also exhibit large coefficients of sorting (table 1).

Sphericity and roundness of 25 grains from each of eight thin-sections were estimated by visual comparison with a standard chart (Krumbein and Sloss, 1951, fig. 4-9). Sphericity of individual grains ranges from 0.3 to 0.9 and round-

ness ranges from 0.1 to 0.9; both characters thus run the gamut of the chart. Variations from slide to slide are small, however. Mean sphericity per slide ranges from 0.54 to 0.66; the grand mean is 0.60. Mean roundness per slide ranges from 0.20 to 0.31; the grand mean is 0.26. A series of *t* tests indicates that none of the sphericity and roundness means per slide departs significantly from the corresponding grand mean (For both sphericity and roundness, maximum *t* = 1.3; minimum *P* = 0.20). The shape of the quartz grains in the Massillon may therefore be characterized as sub-equant and angular to sub-angular.

Grain-contact types were investigated by the method proposed by Taylor (1950). Tangential and long contacts were readily determined, but concavo-convex and sutured types were not. The last two types were therefore combined for analysis. Contacts of 25 grains on each of eight thin sections were counted. The number of contacts per grain ranges from 0 to 8, the mean per slide ranges from 2.7 to 3.7, and the grand mean of eight slides is 3.2. About 14 percent of the contacts are tangential, 49 percent are long, and 37 percent are concavo-convex or sutured. Variation from slide to slide is somewhat larger than expectable sample variation, probably due at least in part to uncertainties arising from the irregular shape of many grains and the abundance of clay matrix.

TABLE 2

Long-axis orientation of elongate grains in thin-section. Two slides, 100 grains each, 30° classes. Zero arbitrarily defined as the long dimension of the slide.

Class (degrees)	Unit 3	Unit 6
0- 29	22%	19%
30- 59	33	19
60- 89	21	12
90-119	9	10
120-149	6	26
150-179	9	14
Total	100%	100%

Elongate grains show a tendency toward orientation in thin-section. Long-axis directions of 100 grains from each of two slides are shown in table 2. A chi-square test (Snedecor, 1946, p. 21-23) indicates that the distribution differs significantly from a random arrangement (Max. χ^2 , unit 3, 16.4, unit 6, 5.2; min. *P*, unit 3, <0.01, unit 6, 0.02). The chi-square test allows an evaluation of the probability that a group of observations of apparently non-random distribution could have been drawn by chance from a larger group (population) with random distribution. Accurate and efficient measurement of this property requires the use of oriented thin sections. Work was therefore suspended pending the collection of oriented specimens.

Structure. Most of the lower bench consists of continuous incline-bedded banks (defined by Andersen, 1931, in Pettijohn, 1949, p. 126) from 0.5 to 5 ft. in thickness. Individual beds range from 1.0 to 20 mm. thick. In the upper part of the lower bench bedding is less regular and some shallow cut-and-fill channels may be seen. Above the lower bench trough-type cross-bedding (defined by McKee and Weir, 1953, p. 387) in lenticular sets up to 3 ft. thick is the rule.

Thickness of the sets of cross- and incline-beds show a nearly log-normal distribution about a mean of 1.2 ft. In general, the thickness of the sets decreases from the bottom of the exposure to the base of the upper bench, where it increases abruptly and remains fairly constant to the top of the quarry wall (table 1). Median grain size shows somewhat similar variation, but there ap-

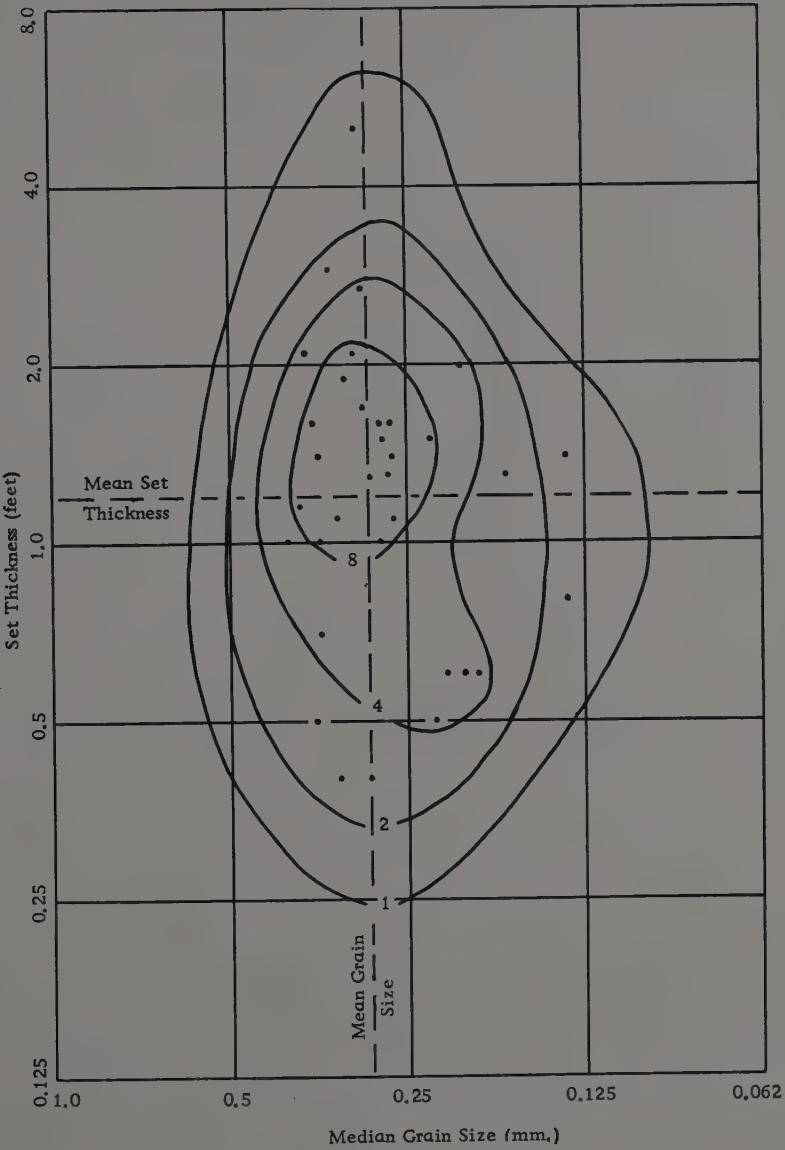


FIGURE 3. Thickness of Sets and Median Grain Size. Contours indicate relative density of observations.

pears to be no direct correlation between set thickness and median size (fig. 3). This suggests independence of the two measures.

Dip-direction distribution of cross- and incline-beds was investigated primarily as a possible criterion for correlation. Five groups of measurements were made, three in the lower bench and two in the upper bench, as shown in the sketch (fig. 1). From 11 to 24 measurements were made in each group. These groups were reduced to equal size by random selection of 11 items from each. Statistics derived are shown in table 3.

TABLE 3
Statistics of samples of dip-directions of cross- and incline-beds.

Statistic (see Snedecor, 1946, chs. 3 and 4)	Lower Bench			Upper Bench	
	South	North	Old Works	South	North
Mean direction ($\bar{x}$)	N 56° W	N 23° W	N 84° W	N 81° E	N 64° E
Number of measurements (n)	11	11	11	11	11
Standard deviation (s)	15°	26°	43°	15°	30°
Standard error ($s\bar{x}$)	4.5°	7.8°	12.9°	4.5°	9°

TABLE 4
Test of precision of individual measurements of dip-direction on the same bedding surface.

Statistic	Gray	Schlein
Mean ($\bar{x}$)	N 76.95° W	N 78.10° W
Number of measurements (n)	20	20
Standard deviation (s)	3.21°	3.18°
Standard error ($s\bar{x}$)	0.72°	0.71°
Difference of means	1.15°	
Standard error of difference of means	1.01°	
<i>t</i>	1.14	
	(not significant)	

Values of *t* and corresponding probabilities were calculated for geologically significant combinations of these groups of measurements. In most cases the value of *t*, which ranges from 1.65 to more than 40.0, indicates significant differences in the means of the populations sampled. Only the two groups from the upper bench indicate a significant probability that two more divergent groups than these could have been drawn from identical populations (*t* = 1.65, *P* = 0.20). It may therefore be inferred that only these groups (which were more closely spaced than any other correlative pair) were drawn from populations which were not significantly different and that cross-bedding studies will probably be of little value in correlation.

The mean direction of the groups of incline-bedding measurements seems not to show any systematic variation, but the standard deviation (table 3) shows a consistent increase northward in both benches. From nearby exposures it is seen

that the medium-grained, incline-bedded graywacke disappears a few hundred feet north of the old works and its place is taken by interbedded gray shale and very fine-grained graywacke. The increased dispersion of incline-bedding dip-directions may result from proximity to the edge of the body of graywacke.

In order to test the precision of dip-direction measurements, a series of 20 measurements was made on the same incline-bedding surface by the author and by Mr. Frederick A. Schlein, who assisted in part of the field work. The statistics

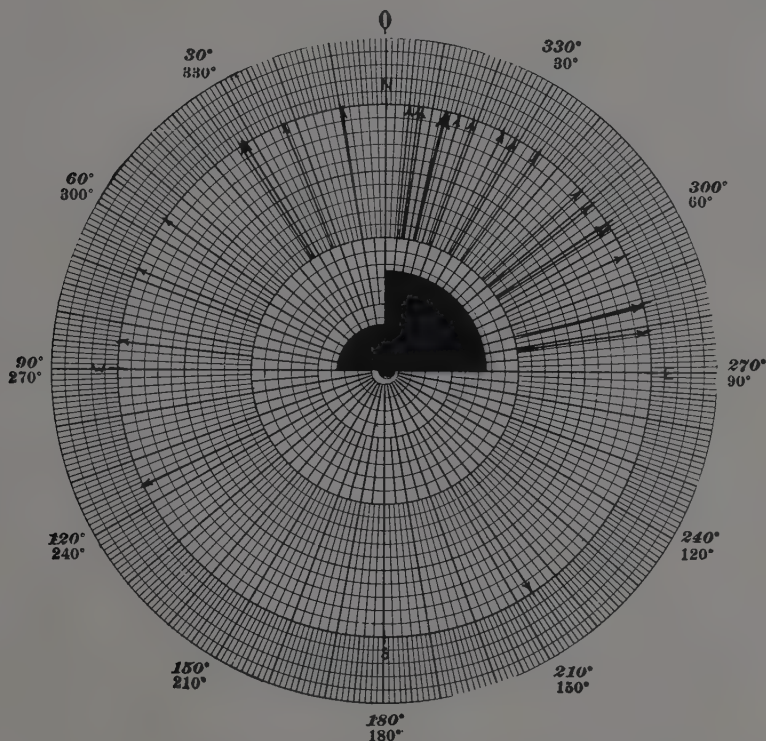


FIGURE 4. Mean dip-directions of cross- and incline-beds in twenty-four exposures of Massillon arenite near the type locality. Summations in each quadrant also show. Heavy arrow shows direction of grand mean.

(table 4) indicate small limits of error for individual measurements and insignificant operator variation.

PETROGENESIS

The source materials of the Massillon arenite cannot be determined on the basis of mineral composition alone because most of the components are of common types and too few grains reveal their origin. The direction of the source may be indicated, however, by a vector property such as dip-direction of cross- and incline-beds. A source material may then be sought in the indicated source area.

In addition to the five groups of dip-direction measurements made at the Warthorst quarry, nineteen other exposures, all within 20 miles of Massillon, were tested (fig. 4). The mean dip-direction for each exposure was calculated from

9 to 30 individual measurements. Fifteen of these means (63 percent) fall in the northeast quadrant and 7 (29 percent) fall in the northwest quadrant. The remaining 2 fall in the southeast and southwest quadrants (4 percent each). A southwestern or southern source of the Massillon of this area is therefore indicated.

Southwest of the type area the Massillon arenite lies at or near the base of the Pennsylvanian system and unconformably overlies Mississippian arenites. Some of the coarser Mississippian clastics may have been a source of the Massillon. The Black Hand sandstone, for example, is a low-rank graywacke similar to the Massillon in composition and texture and is indicated as a possible source because it is well developed in the area from which the Massillon may have been derived.

The environment of deposition of the Massillon arenite can be suggested on the basis of the composition, texture, and structure of the rock. The Massillon is among the most quartzose, best sorted, and most coarse-grained of the many lithologic types in the lower Pennsylvanian; this, together with the numerous unconformities and zones of cut-and-fill, both at the base and within the arenite, indicates a high-energy environment of deposition, such as is characteristic of beaches and stream channels.

Consistency of dip-direction in the cross- and incline-beds is favorable to the hypothesis of a beach environment; marine currents are generally more uniform than fluvial currents. The mean dip-direction is about N 13° E, and is approximately parallel to the strike of the rocks and to the general trend of the contact of the Pennsylvanian with the underlying Mississippian rocks. Longshore currents are therefore probable agents of transport and the physiographic environment may have been an offshore or longshore bar.

Diagenetic changes included the deposition of a small amount of secondary quartz as crystalline overgrowths and the development of flakes and aggregates of sericite (?) and kaolinite (?) which are not distorted and hence probably formed after compaction of the rock. Locally a hydrous iron oxide tentatively identified as goethite was introduced. In one thin-section where goethite is abundant it apparently has shattered and partially replaced the quartz and clay. Replacement of quartz by sericite (?) was indicated in one thin-section, but the time of this replacement could not be determined. It is considered diagenetic (?) primarily because of associated undisturbed interstitial sericite (?) flakes.

Taylor (1950) considers the number and type of grain contacts as an indication of the probable depth of burial of the arenites. Comparison with Taylor's data allows the suggestion that the Massillon may have been buried to a depth of 4,000 ft. or more. Because this is more than twice the known thickness of all possible overlying Pennsylvanian and Permian rocks in the Appalachian Basin, it seems likely that other factors, such as grain shape, may have more influence on grain-contact relations than Taylor recognized.

REFERENCES CITED

- Chayes, F. 1949. A simple point counter for thin-section analysis. *Amer. Mineralogist* 34: 1-11.
- Krumbein, W. C., and L. L. Sloss. 1951. *Stratigraphy and Sedimentation*. W. H. Freeman and Co., San Francisco.
- Krynine, P. D. 1948. The megascopic study and field classification of sedimentary rocks. *Jour. Geology* 56: 130-165.
- McKee, E. D., and G. W. Weir. 1953. Terminology for stratification and cross-stratification of sedimentary rocks. *Bull. Geol. Soc. Amer.* 64: 381-390.
- Newberry, J. S. 1878. Volume III. *Geology*. Geological Survey of Ohio.
- Pettijohn, F. J. 1949. *Sedimentary Rocks*. Harper and Bros., New York.
- Snedecor, G. W. 1946. *Statistical Methods*. Ed. 4. The Iowa State College Press, Ames, Iowa.
- Taylor, Jane M. 1950. Pore-space reduction in sandstones. *Bull. Amer. Assoc. Petroleum Geologists* 34: 701-716.
- Trask, P. D. 1932. *Origin and Environment of Source Sediments of Petroleum*. Gulf Pub. Co., Houston.

THE USE OF N, N, N', N' TETRAKIS (2-HYDROXYPROPYL) ETHYLENEDIAMINE IN THE DETERMINATION OF THE R_2O_3 GROUP IN LIMESTONE

VANCE H. DODSON AND ARTHUR H. BLACK

Department of Chemistry, University of Toledo, Toledo, Ohio

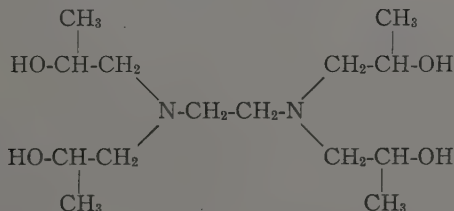
The separation of the R_2O_3 group from alkaline earth and alkali metal ions in the chemical analysis of limestone and dolomite is usually carried out by precipitating the former with ammonium hydroxide as a mixture of hydrous oxides. The coprecipitation of calcium and magnesium ions becomes negligible when a double precipitation procedure is followed. This technique, which is required for accurate analysis, takes from two to three hours per sample.

Various procedures other than that using ammonium hydroxide have been described in the literature for the separation of trivalent metal ions from divalent metal ions in solution. The "basic-acetate" method (Scott, 1939) has met with some success. The use of benzoic acid and ammonium benzoate (Kolthoff *et al.*, 1934) enables one to separate ferric, aluminum, and chromic ions from divalent metals quantitatively with negligible coprecipitation of the latter. Organic nitrogen compounds such as pyridine (Watters *et al.*, 1944), hexamethylenetetramine (Traub, 1946), and urea (Willard *et al.*, 1937) have also been used to effect separations as indicated above.

In a study being made by the authors of N,N,N',N' tetrakis (2-hydroxypropyl) ethylenediamine as a possible chelating agent, it was noted that ferric and aluminum ions were quantitatively precipitated in the presence of this reagent over a pH range of 6.0 to 6.5. In addition, it was found that ferric and aluminum ions were quantitatively separated from calcium and magnesium ions with negligible coprecipitation of the latter ions. This information indicated that the compound might be used as a precipitant for the R_2O_3 group in the analysis of limestone and dolomite.

EXPERIMENTAL PROCEDURE

Reagents. N,N,N',N' tetrakis (2-hydroxypropyl) ethylenediamine, produced by Wyandotte Chemicals Corporation and sold under the trade name of "Quadrol", was dissolved in distilled water and diluted to 1 liter. The quantity of "Quadrol" (29.2 grams) was sufficient to prepare a 0.1 molar solution. "Quadrol" is a tertiary amine alcohol with weakly basic properties. The compound is a viscous liquid, water white and infinitely soluble in water.



N,N,N',N' tetrakis (2-hydroxypropyl) ethylenediamine or "Quadrol"

Standard Iron Solution—7.0225 g. of analytical grade ferrous ammonium sulfate hexahydrate were dissolved in one liter of solution (1 ml. of standard solution = 1 mg. of iron).

Standard Aluminium Solution—1 g. of aluminum wire (spectrographic standard grade) was dissolved in hydrochloric acid and diluted to one liter (1 ml. of standard solution = 1 mg. of aluminum).

Standard Calcium Solution—24.9500 g. of analytical grade calcium carbonate were dissolved in hydrochloric acid and diluted to 500 ml. (1 ml. of standard solution = 20 mg. of calcium).

Standard Magnesium Solution—2.1105 g. of magnesium turnings, analytical reagent grade, were dissolved in hydrochloric acid and diluted to 500 ml. (1 ml. of standard solution = 4.2 mg. of magnesium).

TABLE 1

Determination of Iron (III) and Aluminum in Standard Solutions Using "Quadrol"

Amount of R_2O_3 in Standard Solution	Amount of R_2O_3 Precipitated by "Quadrol"	
	pH = 6.0	pH = 6.5
0.0332 g	0.0336 g.	0.0335 g.
	0.0335	0.0337
	0.0331	0.0330
	ave: 0.0334 g.	ave: 0.0334 g.
0.0664 g	0.0660 g.	0.0662 g.
	0.0663	0.0667
	0.0667	0.0668
	ave: 0.0663 g.	ave: 0.0666 g.

TABLE 2

Determination of Iron (III) and Aluminum in Standard Solutions of Iron (III), Aluminum, Calcium, and Magnesium Using "Quadrol"

Amount of R_2O_3 in Standard Solutions*	Amount of R_2O_3 Precipitated by "Quadrol"	
	pH = 6.0	pH = 6.5
0.0332 g.	0.0338 g.	0.0336 g.
	0.0336	0.0330
	0.0332	0.0338
	ave: 0.0335 g.	ave: 0.0335 g.
0.0664 g.	0.0668 g.	0.0670 g.
	0.0662	0.0665
	0.0670	0.0668
	ave: 0.0667 g.	ave: 0.0668 g.

*Standard solutions contained the equivalent of 0.0700 g. of MgO and 0.2800 g of CaO.

Procedure for R_2O_3 Analysis of Standard Solutions.—Ten milliliter aliquot parts of the standard iron and aluminum solutions were mixed and diluted to approximately 150 ml. with distilled water. Ten milliliter portions of 3 percent hydrogen peroxide were added to oxidize the iron to the ferric state, and the solution was slowly brought to a boil to remove the excess peroxide (Foult *et al.*, 1952). After cooling the solution to room temperature, the standard "Quadrol" solution was added until the desired pH was attained. The pH was measured with a Photovolt line operated electronic pH meter. The solution was again brought to a boil and allowed to stand on a steam plate for 15 minutes. The precipitated hydrous oxides of aluminum and iron were then filtered (No. 41 Whatman filter paper) and washed with warm 1 percent ammonium nitrate

solution. After careful charring of the filter paper, the precipitate was ignited to constant weight at about 1000°C . This same procedure was followed in the analysis of solutions containing 20 ml. aliquot parts of each of the standard aluminum and standard iron and in the analysis of the solutions containing known quantities of aluminum, iron, calcium, and magnesium ions.

Procedure for R_2O_3 Analysis of Limestone and Dolomite.—The sample to be analyzed was thoroughly dried at 110°C , weighed, and ignited at 1000°C for one hour. The silicon dioxide was removed by the usual procedure, using a double dehydration with hydrochloric acid (Kolthoff *et al.*, 1952). After the silica was removed, the solution was diluted to approximately 200 ml. and treated

TABLE 3

A Comparison of the Chemical Analysis for R_2O_3 in Limestone and Dolomite Using Ammonium Hydroxide (Double Precipitation) and "Quadrol"

Sample Number	Per cent R_2O_3	
	Double Ppt'n with NH_4OH	Single Ppt'n with "Quadrol"
	Mean (6 det.)	Ave. dev.
1	0.41%	$\pm 0.02\%$
2	0.87	0.40%
3	1.45	0.85
4	1.72	0.02
5	2.29	0.01
6	3.46	0.03
7	4.56	0.02
8	5.62	0.02

TABLE 4

A Comparison of the Chemical Analysis for R_2O_3 in Limestone Using Double and Single Precipitations with Ammonium Hydroxide

Sample Number ^a	Per cent R_2O_3	
	Double Ppt'n with NH_4OH^a	Single Ppt'n with NH_4OH^b
2	0.87%	1.40%
4	1.72	1.94
5	2.29	2.67
8	5.62	6.25

^aSample number and percentage values were taken from Table 3.

^bAverage of duplicate determinations.

with 3 percent hydrogen peroxide. The excess peroxide was removed by bringing the solution slowly to a boil. The solution was cooled to room temperature and ammonium hydroxide was added until its pH was raised to a value between two and three. The standard solution of "Quadrol" was then added slowly until a pH of 6.5 was reached. The solution was heated to boiling and allowed to stand on the steam plate for 15 minutes. The precipitated hydrous oxides were filtered, washed with warm 1 per cent ammonium nitrate, carefully charred, and finally ignited to a constant weight at about 1000°C . The filtrate was analyzed for its calcium and magnesium content.

RESULTS OF ANALYSIS

The results of the analysis of the standard solutions, using "Quadrol" as the precipitating agent, are reported in table 1 and in table 2. The amounts of R_2O_3 found in eight limestone and dolomite samples when "Quadrol" was used are listed in table 3. These are compared with those values found when the standard double precipitation method with ammonium hydroxide was used. Samples of limestone and dolomite, varying in iron and aluminum oxide content from less

than one half percent to over five percent, were selected for analysis. This wide range of R_2O_3 content was purposely selected to test the accuracy and precision of the procedure. The R_2O_3 content of four of the samples was measured using a single precipitation with ammonium hydroxide in order to determine the extent of the coprecipitation of calcium and magnesium. The results of these analyses are summarized in table 4.

After the separation of the R_2O_3 group with "Quadrol", the filtrate from each of the limestone and dolomite samples was analyzed for calcium and magnesium by the standard method. The amounts of calcium and magnesium found were in good agreement with those obtained when ammonium hydroxide was used as the precipitant for the R_2O_3 group.

DISCUSSION OF RESULTS

The results of the analyses as summarized in table 3 indicate that a single precipitation procedure for the R_2O_3 group ions with "Quadrol" compares very favorably with the standard double precipitation method required when ammonium hydroxide is used. The amount of coprecipitation of calcium and magnesium ions appears to be negligible during the "Quadrol" procedure. It is felt that at least three factors are contributing to this phenomenon.

1. The freshly precipitated hydrous oxides have a tendency to adsorb negative hydroxyl ions on their surfaces and, as a result, assume an overall negative charge. By operating at a pH of less than seven, the number of hydroxyl ions present in solution is reduced and the magnitude of the charge on the precipitate is reduced. This would decrease the attraction of the hydrous oxides toward positive ions in solution.

2. The positive "Quadrol" ion is large and bulky and when attracted to the surface of the charged precipitate would tend to block the approach of other positive ions, thus lowering the concentration of calcium and magnesium ions on the surface of the hydrous oxide.

3. Since the structure of "Quadrol" is similar to that of other chelating agents, it seems possible that some chelation of the calcium and magnesium occurs. Such action would tend to decrease the coprecipitation by reducing the effective concentration of these ions in solution. The chelation, however, appears to be of insufficient strength to prevent the precipitation of calcium as an oxalate. Therefore "Quadrol" does not interfere with the completion of the limestone or dolomite analysis.

The authors are of the opinion that a combination of all three factors is responsible for the favorable results found when "Quadrol" is used in the precipitation of the R_2O_3 group ions.

LITERATURE CITED

- Foulk, C. W., H. V. Moyer, and W. M. MacNevin. 1952. Quantitative Chemical Analysis. Ed. 1. McGraw Hill Co., New York.
- Kolthoff, I. M., V. A. Stenger, and B. Moskovitz. 1934. A benzoate method, a new procedure for the separation of iron, aluminum and chromium from the other ions of the third group and the alkaline earth ions. Jour. Amer. Chem. Soc. 56: 812.
- , and E. B. Sandell. 1952. Textbook of Quantitative Inorganic Chemistry. Ed. 3. Macmillan Co., New York.
- Scott, W. W. 1939. Standard Methods of Chemical Analysis. V. 1. Ed. 5. D. Van Nostrand Co., New York.
- Traub, K. W. 1946. Hexamethylenetetramine in the separation of titanium and columbium. Ind. Eng. Chem. Anal. Ed. 18: 122.
- Watters, J. I., and I. M. Kolthoff. 1944. Determination of manganese after oxidation to trihydrogen pyrophosphatomanganate—use of pyridine to separate iron, chromium, vanadium, and cerium from manganese. Ind. Eng. Chem. Anal. Ed. 16: 187.
- Willard, H. H., and N. K. Tang. 1937. Quantitative determination of aluminum by precipitation with urea. Ind. Eng. Chem. Anal. Ed. 9: 357.

SOME ASPECTS OF THE GLACIAL PHYSIOGRAPHY OF NORTHEASTERN ILLINOIS

ROBERT D. RUDD

Department of Geography and Geology, Ohio University, Athens

The end moraines of northeastern Illinois are considerably varied in form. This variation is primarily the result of differences in the environmental conditions which prevailed during end moraine development. It is the purpose of this paper to consider some of the differences between the end moraines within a restricted portion of this area.

During the Wisconsin glacial stage, northeastern Illinois was invaded repeatedly by ice lobes emanating from the Lake Michigan basin. Although it is believed that deposits representing the Farmdale (Shaffer, Science, 1954, p. 693), Iowan (Shaffer, G. S. A. Bull. 1954, p. 455), Tazewell, and Cary substages (Bretz, 1955, p. 48) are present, the majority of the surface deposits in the area were laid down during Tazewell and Cary time. During Tazewell time the ice advanced westward well past the center of the state, developed an end moraine, and retreated eastward a short distance. This retreat was followed by a series of re-advances and retreats, each of which in general was not as extensive as the one which preceded it. A series of roughly concentric Tazewell end moraines were thus formed, all of which were concave eastward in plan (fig. 1). The Tazewell ice finally retreated an unknown but generally believed considerable distance as that substage ended; and, with the re-advance of the ice, the Cary substage began. The Cary end moraines have an orientation somewhat different from those of the Tazewell substage, being more closely aligned with the present lake shore in this area. They form another series of essentially parallel moraines, each representing a subdivision of Cary time.

Detailed study of these deposits has resulted in the development of a terminology for the several sub-intervals of the Tazewell and Cary substages (Leverett, 1899, pp. 20-1). The last advance of Tazewell ice which left a significant moraine has been designated as Marseilles, and the resulting end moraine the Marseilles moraine. The advance of the Cary ice overran some Marseilles deposits and created the Minooka or outermost Cary moraine. Due to a difference in the direction of motion of the ice which created them the two end moraines meet nearly at right angles in the Yorkville, Illinois Quadrangle; and the following remarks pertain primarily to the deposits of that quadrangle.

MARSEILLES GLACIATION

Although the Marseilles advance was primarily south and westward in Illinois, the ice movement had a northward component in the Yorkville Quadrangle. Hence, within the quadrangle the resulting end moraine was oriented SW-NE with its proximal side facing southeast. Apparently the Marseilles advance consisted of at least two cycles. In addition to the well-defined end moraine designated as the Inner Marseilles, there is a poorly-defined end moraine to the north (fig. 2) which is also considered to have been formed by the Marseilles advance (Powers, 1931). This land-form is designated as the Outer Marseilles end moraine. Its orientation is generally parallel to the Inner Marseilles moraine, and examination of natural exposures and auger samples show the constituent materials of the two to be quite similar. The till of the Outer Marseilles moraine contrasts rather markedly with the Farm Ridge till which adjoins it on the northwest. The latter has a different color, texture, and coherence. In general the Outer Marseilles till sheet is thin, a thickness of 10 ft. being representative. There

is considerably more outwash associated with it than with the Inner Marseilles deposits. The combination of factors is suggestive of an early advance of a shallow lobe during a relatively warm climate, a stand of short duration forming the Outer Marseilles moraine, a limited retreat, and then a vigorous re-advance of Marseilles ice to form the Inner Marseilles end moraine. The relative ruggedness of its upland, its elevation above the surrounding areas—150 ft. in places—and the sharp descent of the distal slope make the Inner Marseilles one of the best examples of an end moraine in northeastern Illinois.

MINOOKA GLACIATION

The Minooka end moraine, a north-south feature (fig. 2) extending all along the east edge of the quadrangle, intersects the Inner Marseilles moraine near the center of that edge. Representing an early phase of the Cary ice advance, this

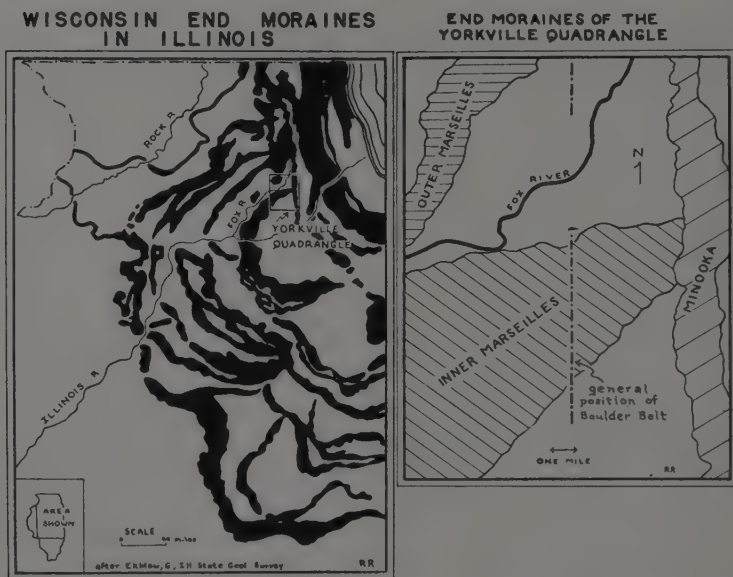


FIGURE 1 (left) and FIGURE 2. Some aspects of the glacial physiography of northeastern Illinois.

moraine differs from both the previously mentioned ones. It is a much more distinctive feature than the Outer Marseilles moraine in that it is more continuous and stands higher above its surroundings. It is less impressive than the Inner Marseilles, however, seldom rising over 60 ft. above the adjoining plain. It does not have the ruggedness of upland common to the Inner Marseilles either; indeed parts of the crest of this moraine seem exceedingly flat for a landform of this type. The relative flatness of summit of this moraine has been commented on by several writers, and over-riding of the moraine by Minooka ice or deposition beneath the ice have been suggested as explanations (Leverett, 1899, p. 327).

Actually the surface expression of most Minooka deposits is rather more subdued than that of many similar deposits, so that it must be recognized that the present surface may be typical of a Minooka end moraine.

THE BOULDER BELT

The possibility of overriding seems especially interesting, however, when two other factors are considered. The first of these is the uncharacteristically subdued crest of the Inner Marseilles moraine near its junction with the Minooka moraine. This subdued portion extends a little more than four miles west of the intersection of the two moraines. The other factor is the "boulder belt" described by Leverett (Leverett, 1899, p. 325). This feature is described as a discontinuous belt of boulders, mostly crystalline, with no till recognizably associated with it. It was oriented north-south, parallel to the Minooka moraine and about four or five miles west of it (fig. 2). Portions of this belt were found in the adjoining quadrangles both north and south of this one. Within this quadrangle it originally extended a distance of eight or nine miles, its northern end extending across the Inner Marseilles moraine. Some fifty years of farming in this agriculturally rich area have resulted in the removal and redistribution of most of the boulders. Many of them, however, are to be found collected in pastures and areas of poor drainage; and local residents can remember the boulder belt as a frequently discussed problem topic. Some of the boulders are rather large, one angular metamorphic being almost five feet long. The concept of overriding of the Minooka and Inner Marseilles moraines by Minooka ice to the position of the boulder belt may be the explanation for the several features mentioned above.

Although glacial advance is not always accompanied by end moraine formation, in general it seems to have so been in this area. The absence of a recognizable end moraine here thus raises a question.

However, the absence of a ridge of drift associated with the boulder belt is only one of several problems encountered in attempting to establish this concept. Not only is there no true end moraine; it is difficult to find a till sheet clearly associated with the boulder belt. This problem is due in part to the marked similarity in physical characteristics of Marseilles and Minooka tills. The depth of leaching in both is between 2 and 3 ft. The color of oxidized or unoxidized samples of the two tills is very similar. No appreciable difference in stoniness or lithology was found. Events subsequent to Minooka time serve to complicate the situation further. The areas of till plain west of the Minooka end moraine were flooded by large quantities of post-Minooka waters (Ekblaw and Athy, 1925, p. 417) which are likely to have eroded and/or buried most of what there was in the way of a till sheet. These waters were responsible also for the discontinuous nature of the boulder belt.

An alternate explanation of the relationships between end moraines mentioned earlier seems possible for several reasons. Just north of the point where the Marseilles moraine meets the Minooka there is a sand and gravel plain sloping westward away from the Minooka moraine. This is believed to be an outwash plain formed while the ice was halted at the position of the Minooka moraine. Parts of this plain stand above the elevations affected by the post-Minooka floodwaters. Overriding of the Minooka and Inner Marseilles moraines by Minooka ice should have left some evidence of its occurrence on this plain. Also, the relative steepness of the distal slope of the Minooka moraine seems indicative of an unmodified surface rather than one which has experienced overriding.

CONCLUSION

That the Minooka ice did at one time move west of the position of the Minooka moraine seems indicated by the altered surface of the Inner Marseilles moraine,

the boulder belt, and the coincidence in location between the two. The consideration of these several factors leads to the conclusion that the sequence of events associated with the Minooka glaciation may well have been a repetition of the Marseilles glaciation. The original Minooka advance was made by a thin lobe of ice and with a somewhat warmer climate than was common to the bulk of Minooka time. The ice advanced to the position of the boulder belt, overriding and altering slightly a portion of the Inner Marseilles moraine. The boulder belt was left marking the farthest westward advance of Minooka ice, and this ice retreated rapidly by melting. The retreat of Minooka ice for a short distance was followed by a more vigorous re-advance, vigorous enough to eradicate any portion of the Inner Marseilles moraine which may have extended east of the Minooka moraine, and to create a fairly strong topographic feature in the Minooka end moraine. The relative smoothness of parts of the crest of the moraine may be either due to deposition beneath the ice, or simply a typical Minooka surface.

LITERATURE CITED

- Bretz, J. H.** 1955. Geology of the Chicago Region. Ill. Geol. Surv. Bull. 65. Part II.
Ekblaw, G. E., and L. F. Athy. 1925. Glacial Kankakee Torrent in Northeastern Illinois. Geol. Soc. Amer. Bull. 36: 417-427.
Leverett, F. 1899. The Illinois Glacial Lobe. U. S. Geol. Surv. Mon. 38.
Powers, W. E. 1931. Geology of the Geneva, Illinois Quadrangle. Ph.D. Diss. Harvard University.
Shaffer, P. R. 1954. Farmdale Drift. Science 119: 693-694.
 ———. 1954. Extension of Tazewell Glacial Substage of Western Illinois into Eastern Iowa. Geol. Soc. Amer. Bull. 65: 443-456.

Why Not Survive. *Michael W. Straus.* Simon and Schuster, New York. 1955. xi + 273 pp. \$4.00.

The message of this book is optimistic in spite of the appalling record of the pillage and wasteful despoliation of our natural resources. Mr. Straus is a former newspaperman and as First Assistant Secretary of the Interior and as U. S. Commissioner of Reclamation has had immense opportunity to find out what goes on behind the scenes in our costly and sometimes unwise government. As the title suggests there may here be an answer both to Vogt's "Road to Survival" and deCastro's "The Geography of Hunger". Mr. Straus believes we can continue on at our high living standards and has plenty of suggestions to offer. His book makes pithy controversial reading on a popular and important subject.

ADOLPH WALLER

Introduction to Chemical Engineering. *W. L. Badger and J. T. Bancroft.* McGraw-Hill Book Company, Inc., New York. First Edition, 1955. ix+753 pp. \$9.50.

This book is intended as an introductory text to acquaint the beginning engineer and technologist with the elements of chemical engineering. The plan is the conventional one of dividing the subject into a series of the more important unit operations associated with industrial chemical processes. Each of these operations are described, keeping in mind a reasonable balance between the theory and the engineering application. While the text is sufficiently free from mathematical envelopments to be understood by the average undergraduate, nevertheless, it is rigorous and sound enough to provide a firm foundation for advanced work.

The text is well illustrated. There are numerous graphs of engineering data and equipment illustrations. In the case of the latter, cross-sectional diagrams are given showing in detail the construction of the equipment. The inclusion of numerical illustrative examples throughout the text and an adequate number of problems to be solved at the end of each chapter adds greatly to the value of the book.

This is an excellent book and can be highly recommended as an undergraduate text.

WEBSTER B. KAY.

CYTOLOGICAL OBSERVATIONS ON PSELAPHID BEETLES

GEORGE H. MICKEY AND ORLANDO PARK

Department of Biological Sciences, Northwestern University, Evanston, Illinois

Little information is available on the life cycles and reproductive stages of Pselaphidae although considerable taxonomic and ecological data on the North American fauna have been published (Park, 1953). Consequently a study was initiated some three years ago to determine the condition of the gonads and germ cells of several species collected at different times of the year. The present report deals primarily with two species, *Batrisodes globosus* (LeConte) and *Pselaphus fustifer* Casey, in which male germ cell development and chromosome numbers are described. Some observations are given on the breeding season of three other species, *Reichenbachia peregrinator* Casey, *Reichenbachia subsimilis* Casey and *Pilopius lacustris* Casey.

MATERIALS AND METHODS

Collection of adult pselaphids and their identification were made by Park. The collection site was Peacock Prairie, a locality that has provided two natural population studies reported previously (Park *et al.*, 1949, 1953). The beetles were brought to Cresap Biological Laboratory where they were dissected and prepared for cytological study by Mickey.

The testes were removed in isotonic saline solution, then transferred to a depression slide and immersed in aceto-orcein stain for ten minutes. The glands were placed on a microscope slide in a fresh drop of stain and squashed under a number 1 cover glass. The temporary smear preparation was sealed with melted paraffin-gum mastic mixture and studied at once. Camera lucida drawings and photomicrographs were made from the temporary preparations. Later the slides were made permanent by the method of Conger and Fairchild (1953) which involves freezing the temporary slide on a block of dry ice, removing the cover glass by lifting a corner with a razor blade, transferring the slide to 95 percent ethyl alcohol, absolute alcohol, then mounting in Euparal.

All slides were studied under Spencer apochromatic 90 X oil immersion objective and paired compensating 20 X oculars. The photomicrographs were taken with the same microscope using a monocular tube and 15 X compensating ocular and a Leitz Micro-Ibso attachment with Leica 35 mm. camera. Microfilm was used and the negatives enlarged in printing.

CONDITION OF GERM CELLS AND BREEDING SEASON

Our general ignorance concerning the life cycles of pselaphid beetles is reflected by the fact that no single species has a known life history from copulation to mature adult. This is significant when we realize that the family is broadly distributed over the world, often in high population density, and embraces at least 5,500 described species. Böving and Craighead (1931) described and illustrated presumably mature larvae of *Batrisodes monstrosus* (LeConte) and *Euplectus confluent* LeConte; Besuchet (1952) described and illustrated mature larvae and pupae of *Plectrophloeus* taken in deep soil in Switzerland. The meager information has been summarized by Park (1942, 1947) and Jeannel (1950).

At the latitude of Peacock Prairie (northeastern Illinois) the pselaphid population appears to have two seasonal peaks of freshly-pupated adults, one in the spring (May to mid-June) and one in the autumn (mid-September to mid-October). These callow or teneral individuals are easily distinguished as their integuments are light yellow, translucent and thin (Park, *et al.*, 1953).

In this paper we are concerned with the vernal peak chiefly. The copulation period probably fluctuates with the seasonal variation of environmental factors but includes as early as March 31 (1955) when a pair of *Pselaphus fustifer* were observed in copulation, to as late as April 10 (1952) when copulation was noted for a pair of *Reichenbachia subsimilis*.

Additional inferences may be drawn (See Discussion) from the condition of the gonads and the presence of mature sperm in the males. A male of *Pselaphus fustifer* killed on May 10, 1952, revealed only a few dividing cells but many mature sperm in the testes. A male of *Batrisesodes globosus* was dissected on October 10, 1953, and mature sperm were present. On November 14, 1953, a male *Reichenbachia subsimilis* was found to have abundant mature sperm in testes and vasa deferentia; only a few dividing cells were observed. Several specimens of *P. fustifer*, *R. subsimilis*, and *Pilopius lacustris* were examined on March 31, 1955, and no mitotic figures were noted in any; mature sperm were present in all. One male of each of *P. fustifer*, *B. globosus*, and *R. peregrinator* were killed on May 26, 1955, and all showed active development of germ cells and presence of mature sperm.

SPERMATOGENESIS

The pattern of spermatogenesis in the two species, *B. globosus* and *P. fustifer*, follows that described for most insects. The youngest spermatogonia arise in the apical end of the testicular follicles and become grouped into cysts of synchronously dividing cells. The cysts are progressively older as the vas deferens is approached, thus providing a rough seriation of stages in order of their development.

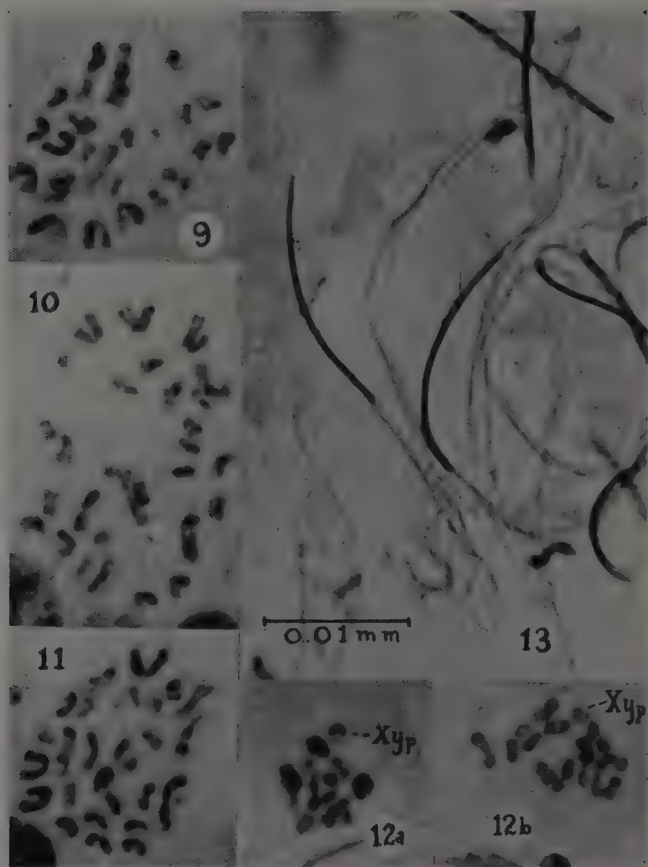
The metaphase plates of dividing spermatogonia provide accurate counts of the diploid chromosome numbers of the different species. Figure 1 shows a spermatogonial resting stage of *B. globosus* in which the X chromosome and pro-centric areas of other chromosomes are positively heteropycnotic. The pachytene stage illustrated in figure 2 shows polarization of chromosomes toward the heteropycnotic X which lies against the nuclear membrane. Two spermatogonial metaphases of *B. globosus* are shown in figures 3 and 4 and photographs of the same cells are exhibited in figures 9 and 10. Fourteen pairs or 28 chromosomes are evident. The Y chromosome is identified as the smallest in the group, although the X chromosome is not recognizable at this stage. All chromosomes are metacentric or nearly so, although one pair of the larger and one pair of smaller ones have noticeably unequal arms. Figure 11 depicts another spermatogonial metaphase. Metaphases of the first maturation division showing the fourteen tetrads are illustrated in figures 5, 6 and 7. Most chiasmata are terminalized but the largest chromosome at least retains one interstitial chiasma. The sex chromosomes are obvious; the larger X and the minute Y chromosome, both with median centromere, are associated by means of two terminal points, giving the parachute configuration found in so many beetles by Smith (1949, 1953). They appear to exhibit slight negative heterochromaticity. A photograph of this stage is shown in figure 12. Figure 8 depicts a mature spermatozoön of *B. globosus* and a photograph of a similar stage appears in figure 13. Its structure resembles closely that described for the bruchid, *Bruchus quadrimaculatus* Say, (Mickey, 1935) except that the acrosome is more prominent in *Batrisesodes*.

Pselaphus fustifer has fifteen pairs of homologous chromosomes or thirty as the diploid number. Figures 14 and 15 delineate spermatogonial divisions and the same cells are photographed in figures 20 and 21. Here, as in *B. globosus*, the Y chromosome is the smallest in the entire group. Likewise all chromosomes are metacentric with two pairs being clearly heterobrachial. Fifteen tetrads are seen in figures 16 and 17 in which the sex chromosome pair shows particularly well. The longest pair of chromosomes is seen to have at least three chiasmata in the tetrad (fig. 17). The same two cells are photographed in figures 22 and 23.



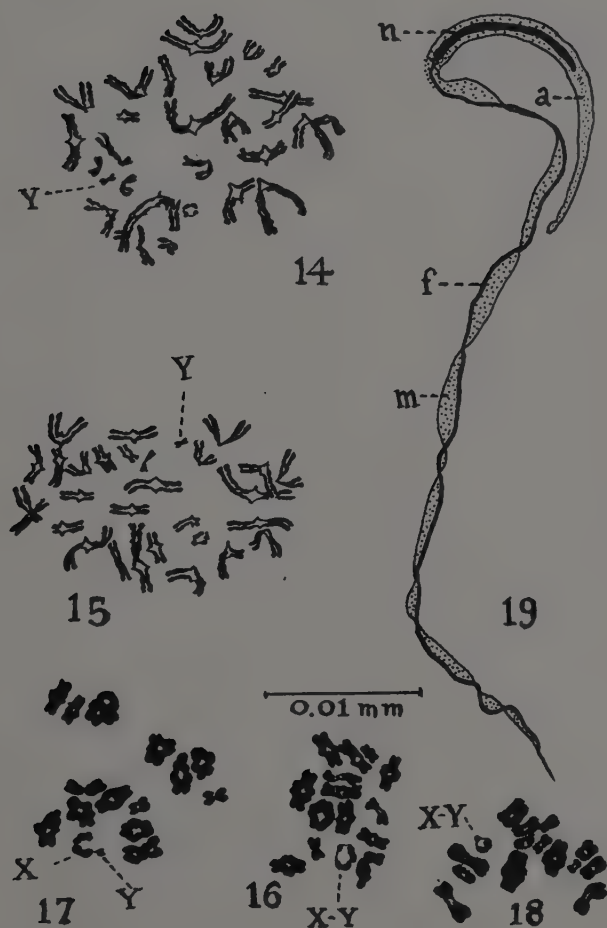
All figures are camera lucida drawings and all are made at the same magnification; scale is indicated.

1. Spermatogonial resting stage; X chromosome and procentric areas of other chromosomes positively heteropycnotic.
2. Primary spermatocyte in pachytene showing polarization of chromosomes toward the heteropycnotic X chromosome which lies against the nuclear membrane.
3. Spermatogonial division of *Batrisodes globosus* showing the 28 chromosomes (14 pairs) in the diploid group.
4. Another division figure of *B. globosus* spermatogonium. The minute Y chromosome is indicated.
5. First maturation division metaphase of *B. globosus* showing the 14 tetrads and identifying the X_{yp} pair (parachute type).
6. Metaphase I of *B. globosus*.
7. Another figure of first maturation division of *B. globosus*.
8. A mature spermatozoön of *B. globosus*: a, acrosome; n, nucleus; f, axial filament of tail; m, undulating membrane of tail.



All photomicrographs made on 35 mm. microfilm and all enlarged equally for printing. Scale is indicated.

9. Spermatogonial metaphase of *Batrisodes globosus*. Drawing of this same cell is shown in fig. 3.
10. Similar division figure of spermatogonium (*B. globosus*). Drawing of this same cell is shown in fig. 4.
11. Another spermatogonial metaphase of *B. globosus*.
- 12a. Metaphase of first maturation division of *B. globosus* showing the parachute type sex chromosomes.
- 12b. Late metaphase or beginning anaphase I.
13. Mature sperm of *B. globosus*.



14. Spermatogonial metaphase of *Pselaphus fustifer*. All thirty chromosomes show clearly and the positions of the centromeres are obvious. The small Y chromosome is identified.
15. Another dividing spermatogonium of *P. fustifer*. These same cells are photographed in figs. 20 and 21.
16. Metaphase of first meiotic division of *P. fustifer* showing the 15 tetrads, among which the XY pair stand out distinctly.
17. Similar figure of another spermatocyte (*P. fustifer*). The Y is detached from the X on one end. These two cells are shown in photomicrographs in figs. 22 and 23.
18. Another metaphase I of *P. fustifer* showing the parachute arrangement of the X and Y chromosomes.
19. Nearly mature spermatozoön of *P. fustifer*: a, acrosome; n, nucleus; f, axial filament; m, undulating membrane.

Figure 18 illustrates another metaphase of the first meiotic division. In the same field with the tetrads in fig. 23 is a resting nucleus of a spermatogonium in which the heterochromatic X chromosome is seen lying at one margin of the nucleus. Figure 24 is another metaphase of the first meiotic division in *P. fustifer*.

A mature spermatozoön of *P. fustifer* is shown in figure 19 and a photograph of a similar stage in figure 25. The prominent acrosome, compact nucleus and tail with axial filament and undulating membrane are visible in both drawing and photograph.

POLYPLOID GERM CELLS

Several polyploid spermatogonia and spermatids were noted in both *B. globosus* and *P. fustifer*. Figure 26 shows two early spermatid nuclei of the former species lying side by side, the one having the normal haploid number of fourteen chromosomes and the other about twice as many. A tetraploid spermatogonium of *P. fustifer* containing two heterochromatic X chromosomes and surrounded by normal diploid nuclei is seen in figure 27. Figure 28 demonstrates a group of early spermatid nuclei, most of which are normal haploid but two of which are diploid, and one tetraploid. Later stages of metamorphosis of spermatids may be highly polyploid as seen in figures 29 and 30. These large nuclei should be compared with the normal haploid nuclei in the same field of view. Presence of polyploid germ cells in these pselaphid beetles resembles the situation in grasshoppers (Mickey 1942a, 1942b, 1944, 1945, 1947 and Gremillion, 1947).

DISCUSSION

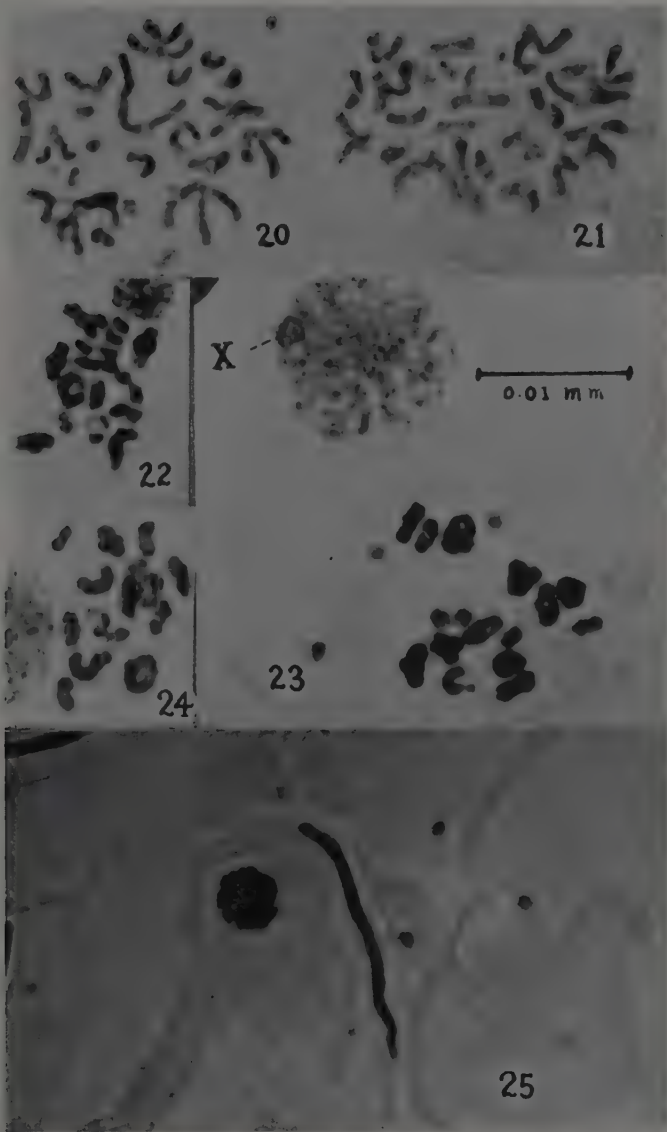
Judging from the condition of male gonads reported here, the number of dividing germ cells and presence of mature sperm in testes and vasa deferentia, it appears that there is a mating season for five species of Pselaphidae under discussion during the spring and early summer. The greatest mitotic activity of germ cells has been observed in May. The copulating pair of *P. fustifer* observed on March 31, 1955, in which the male had abundant sperm, demonstrates that mating can occur in the Chicago area in early spring; copulation of a pair of *R. subsimilis* on April 10, 1952, tends to suggest an extended mating season, or a seasonal adjustment with local conditions. It would be desirable to check specimens several times each month throughout several years, in parallel with data on the microenvironmental meteorology to be certain of the length and onset of the breeding season.

All observations on spermatogenesis have been made on adults, some of which appeared to be rather old as judged by the state of their reproductive systems. This fact may help to explain the relative paucity of dividing germ cells in most of the specimens. In order to obtain the maximum number of mitotic and meiotic figures, probably just-pupated adults (callows or tenerals) are needed. It would be interesting to examine pupae in this regard were they to be discovered.

No members of the Pselaphidae are cited in the most complete and recent list of chromosome numbers of Coleoptera by Smith (1953) who gives information on 340 species including 179 genera and 33 families. He considers the typical formula

EXPLANATION OF FIGURES

20. Spermatogonial metaphase of *P. fustifer*. Same cell drawn in fig. 14.
21. Similar division of *P. fustifer* spermatogonium. Drawing of this cell shown in fig. 15.
22. First meiotic metaphase of *P. fustifer*. Drawing of this cell shown in fig. 16.
23. The 15 tetrads in metaphase I of *P. fustifer*. Drawing of this cell shown in fig. 17. The heterochromatic X chromosome is visible in an adjacent resting nucleus.
24. Another metaphase I (*P. fustifer*).
25. Nearly mature spermatozoön of *P. fustifer*. A young spermatid nucleus lies between the spermatozoön nucleus and its recurved tail.



for beetles to be $9\text{ AA} + \text{Xy}_p$ (1950a, 1950b and 1952a) or $2n = 20$. The pselaphids dealt with here have 28 and 30, and in the most closely related family of beetles, the Staphylinidae, the known numbers range from 18 to 44. Smith (1952b) discusses the types of changes which lead to diversity of chromosome numbers among beetles. An increase in number of chromosomes may arise by "fragmentation", by which is meant misdivision or break of the centromere thus producing telocentric chromosomes. Since telocentrics are probably unstable, they may become metacentric by inversion or transposition.

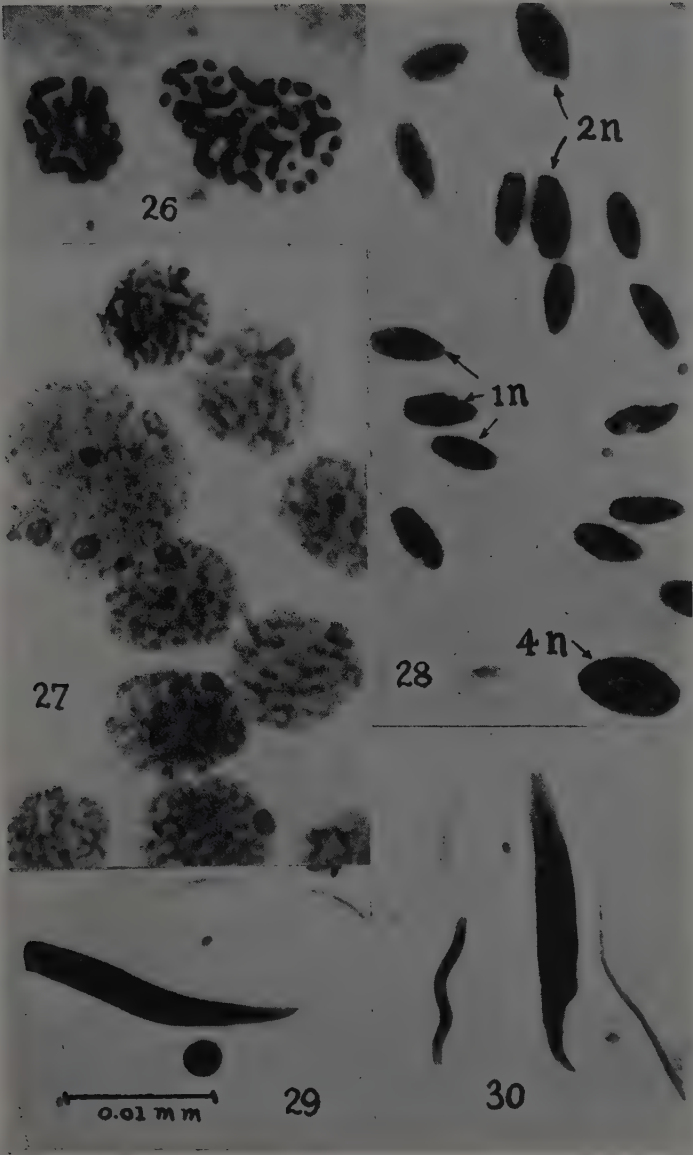
A variety of situations with regard to the sex chromosomes exist in Coleoptera (Dutt, 1953, and Smith, 1953): (1) multiple sex chromosomes, (2) X and Y indistinguishable or unidentified, (3) relatively small sex chromosomes, (4) large X chromosome with the Y missing, (5) neo-XY, derivative or complex sex-determining mechanism, (6) rod-type association between X and Y at metaphase I, (7) centric association between the two, and (8) "parachute-type" association of X and small Y chromosome. Smith (1949) thinks that the parachute type is the primitive system in the order, whereas the XO and X-large Y are derivative systems.

The sex chromosome mechanism appears to be alike in *B. globosus* and *P. fustifer*; that is, of the Xy_p or parachute type. In this connection it is of interest to note that a Bahaman species, *Dalmomelba cazieri* Park, was thought to have the XY type of sex determination on the basis of genetic behavior of eye and wing characters in the two sexes (Park, 1954).

The significance of the rather common occurrence of polyploid spermatozoa in insects is problematical. Diploid eggs of *Drosophila melanogaster*, when fertilized by haploid sperm, give rise to triploid individuals. It is not known whether diploid (or higher ploid) sperm function or not. In a study of the Louisiana lubber grasshopper, *Romalea microptera*, (Mickey, unpublished) hundreds of young nymphs were examined to determine if any were polyploid. None was found. It may be postulated that such sperm seldom if ever fertilize an egg even though the polyploid spermatids undergo metamorphosis and assume the structure of mature sperm. Several possible reasons may be cited, among which are (1) unfavorable competition of the polyploid sperm with normal haploids and (2) inability to enter the egg through the micropyle because of their large size. Perhaps the micropyle of a diploid egg would be large enough to accept a diploid spermatozoön, and such an event could occur among the enormous numbers of germ cells produced by a species over long periods of time, and thus give rise to a tetraploid individual. However, diploid gametes from such an individual, when united with normal haploid gametes, would give rise to triploids which would be highly sterile. Segregation of chromosomes in the germ cells of an autotetraploid is notoriously irregular resulting in much sterility because of deficiency-duplication gametes. Furthermore, as pointed out by Muller (1925) imbalance of sex chromosomes militates against establishment of polyploid strains among animals.

EXPLANATION OF FIGURES

26. Two young spermatid nuclei of *B. globosus*; the one on the left containing the haploid number of 14, the one on the right approximately twice as many chromosomes.
27. Tetraploid spermatogonium of *P. fustifer* containing two heterochromatic X chromosomes. The other nuclei in this figure are diploid and contain only one heterochromatic X chromosome.
28. A group of metamorphosing spermatids of *P. fustifer*, most of which are normal haploid, but two of which are diploid and one tetraploid.
29. Spermatid nucleus of *P. fustifer*, much further along in metamorphosis, which is obviously highly polyploid.
30. Another highly polyploid nucleus of *P. fustifer* spermatid. A (probably) diploid nucleus lies to the left and a normal haploid nucleus to the right.



SUMMARY

1. A breeding period during early spring for the five species of pselaphid beetles, at the latitude of Northern Illinois, is established on the basis of condition of gonads and presence of mature sperm in the males, copulation dates, and the appearance of callow individuals in late spring and early summer.

2. The diploid chromosome numbers are determined for *Batrissodes globosus* as 28 and for *Pselaphus fustifer* as 30.

3. An Xy_p chromosome mechanism of sex determination in these species is identified; the minute Y is associated with the X at metaphase I by two terminal contact points, thus resembling a parachute.

4. The structure of mature sperm in *B. globosus* and *P. fustifer* is described.

5. The occurrence of polyploid germ cells in these two species is noted.

LITERATURE CITED

- Böving, A. G., and F. C. Craighead. 1931. An illustrated synopsis of the principal larval forms of the order of Coleoptera. Reprinted in book form from Entomologica Americana. 11: 1-351.
- Besuchet, C. 1952. Larves et nymphes de *Plectophloeus*. Mitt. Schweizerischen Ent. Gessell. 25: 251-256.
- Conger, A. D., and L. M. Fairchild. 1953. A quick-freeze method for making smear slides permanent. Stain. Tech. 28: 281-283.
- Dutt, M. K. 1953. Chromosomes of *Opatroides vicinus* Fairm. (Coleoptera: Tenebrionidae) Current Sci. 22: 278.
- Gremillion, D. 1947. Polyploidy in the germinal tissue of *Melanoplus femur-rubrum* (DeG.). Proc. Louisiana Acad. Sci. 7: 80-81.
- Jeannel, R. 1950. Coléoptères psélaphides. Faune de France 53: 1-421.
- Mickey, G. H. 1935. Spermioteleosis of *Bruchus quadrimaculatus* Say. Jour. Morph. 57: 147-167.
- . 1942a. Polyploid gametes in the Louisiana lubber grasshopper. Proc. Louisiana Acad. Sci. 6: 82.
- . 1942b. Polysomaty and polyploid gametes in *Romalea microptera*. Genetics 27: 156.
- . 1944. Synopsis and behavior of chromosomes in polyploid male germ cells of *Romalea microptera* (Beauv.). Genetics 30: 15.
- . 1945. Additional polyploid and mixoploid tissues in nymphs of the Louisiana lubber grasshopper, *Romalea microptera* (Beauv.). Proc. Louisiana Acad. Sci. 9: 39-57.
- . 1947. Division cycle in grasshopper chromosomes. Proc. Louisiana Acad. Sci. 10: 49-66.
- Muller, H. J. 1925. Why polyploidy is rarer in animals than in plants. Amer. Nat. 59: 346-353.
- Park, O. 1942. A study in Neotropical Pselaphidae. Northwestern Univ. Studies Biol. and Med. No. 1: 1-403.
- . 1947. The pselaphid at home and abroad. Sci. Monthly. 65: 27-42.
- . 1953. Discrimination of genera of pselaphid beetles of the United States. Bull. Chicago Acad. Sci. 9: 299-331.
- . 1954. The Pselaphidae of South Bimini Island, Bahamas, British West Indies (Coleoptera). Amer. Mus. Novitates. 1674: 1-25.
- , S. Auerbach, and Marie Wilson. 1949. Pselaphid beetles of an Illinois prairie: the fauna and its relation to the prairie peninsula hypothesis. Bull. Chicago Acad. Sci. 8: 267-276.
- , and ———. 1953. Pselaphid beetles of an Illinois prairie: the population. Ecol. Monographs. 23: 1-15.
- Smith, S. G. 1949. Evolutionary changes in the sex chromosomes of Coleoptera. I. Wood borers of the genus *Agilus*. Evolution. 3: 244-357.
- . 1950a. Evolutionary changes in the sex chromosomes of Coleoptera. II. Flour beetles of the genus *Tribolium*. Genetics. 35: 693.
- . 1950b. The cyto-taxonomy of Coleoptera. Canadian Ent. 82: 58-68.
- . 1952a. The cytology of *Sitophilus* [Calandra] *oryzae* (L.), *S. granarius* (L.), and some other Rhynchophora (Coleoptera). Cytologia. 17: 50-70.
- . 1952b. The cytology of some tenebrionid beetles (Coleoptera). Jour. Morph. 91: 325-364.
- . 1953. Chromosome numbers of Coleoptera. Heredity. 7: 31-48.

THE GENUS *DICHOXENUS* HORN (COLEOPTERA, CURCULIONIDAE)

15. A contribution to the knowledge of the Curculionidae

ELBERT L. SLEEPER

Department of Zoology and Entomology, The Ohio State University, Columbus, 10

During the past few years a number of members of the genus *Dichoxenus* Horn have been sent to the author in material for identification. Several new forms were found and they are herewith published.

Very little work has been done on the genus *Dichoxenus* since the original description of the genus and genotype by Horn in 1876. In 1910 and 1913 Pierce mentioned the genus only briefly in keys to related genera. In 1927 Buchanan placed *Anamelis setosus* Blatchley in the genus. Other than the above works no systematic work has been done on the genus.

Dichoxenus was placed in the tribe Ophryastini of the Otiiorhynchidae by Horn when he described the genus. Pierce in 1910 placed it in the group Strangaliodes, tribe Ophryastini of the Otiiorhynchinae. In 1913 he placed it in the tribe Tropiphorini of the subfamily Eremninae, family Brachyrhinidae. Schenkling and Marshall (1931) placed *Dichoxenus* in the subfamily Leptopinae, tribe Leptopini of the Curculionidae. After study of foreign material it seems that the genus is properly placed in the Leptopinae as indicated by Schenkling and Marshall.

All members of this genus examined (196 individuals) were female. A spermatheca is present in all species. This would seem to indicate that males are present or were probably existent in the not too distant past.

All measurements of body length were taken from the dorsal view beginning at the anterior margin of the eyes and extending to the apices of the elytra. Measurements of the rostrum were made from the lateral view along the chord of the dorsal side from the basal impression to the apical end of the rostrum with the mandibles in a closed position. Those of the pronotum are along the median line. The term pronotum is applied to the disc of the prothorax.

Dichoxenus Horn

Dichoxenus Horn 1876, p. 39. LeConte and Horn 1883, p. 444. Pierce 1910, p. 348; 1913, p. 380. Buchanan 1927, p. 184.

Rostrum longer and slightly narrower than the head, separated from the head by a deep transverse impression, feebly convex above, subquadrangular, tip emarginate, nasal plate sharply defined by a distinct rim. A deep groove in the basal half above the scrobes. Scrobes lateral, deep, well defined, arcuate and passing rapidly beneath the head at a distance in front of the eyes. Antennal insertion subapical; scape gradually clavate, scaly, scarcely passing the anterior border of the eyes; funicle 7-segmented, segments 1 and 2 subequal, the first stouter, 3-7 obconical the seventh segment not contiguous with the club; club elongate oval. Eyes oval, oblique, coarsely granulate and flattened. Prothorax oval, broader than long, truncate at apex and base, ocular lobes broad and moderately prominent. Scutellum indistinct or scarcely visible. Elytra oval, not wider at base than prothorax. Metasternal side pieces indistinct. Intercoxal process of abdomen broad, slightly arcuate in front. Second segment of abdomen shorter than the two following united, separated from the first by a deep, straight suture. Anterior and middle tibiae feebly mucronate and dentate within. Corbels of hind tibiae open. Tarsi normal and densely pubescent beneath. Claws free, simple and divergent. Body scaly and with short erect setae.

Genotype.—*Dichoxenus setiger* Horn by monotypy.

THE OHIO JOURNAL OF SCIENCE 56(3): 165, May, 1956.

Key to the species of Dichoxenus in America north of Mexico.

1. Pronotum deeply scarred and rugosely tuberculate. 2
- 1¹. Pronotum more or less smooth, not deeply scarred (some specimens may have the flanks more or less rugose), the surface densely covered with small granular tubercles. 3
2. Raised setae of elytral intervals recumbent, broadly clavate; form elongate-oval. *occidentalis* n. sp.
- 2¹. Raised setae of elytral intervals erect and very feebly clavate; form oblong-oval. *setiger setiger* Horn
3. Rostrum prominently tricarinate, appearing smooth; pronotum not conspicuously tuberculate due to the close fit of the non-overlapping scales; striae not or feebly impressed; waxy exudation absent from surface; spermatheca as in fig. 7. *tessellatus* n. sp.
- 3¹. Rostrum not prominently tricarinate, appearing roughened, pronotum with tubercles more or less conspicuous through the overlapping scales; striae moderately impressed; waxy exudation present with the scales. 4
4. Nasal plate U-shaped not pointed at the uppermost limit; striae punctures small, separated by their own diameter on the disc; setae of elytral intervals narrowly clavate (fig. 6); spermatheca as in fig. 8. *setosus* (Blatchley)
- 4¹. Nasal plate more V-shaped, pointed at uppermost limit; striae punctures large, separated by one-half their diameter on disc; setae of elytral intervals setose, very feebly clavate (fig. 5); spermatheca as in fig. 3. *setiger arkansensis* n. ssp.

Dichoxenus occidentalis n. sp.

Figures 1 and 4

Female.—Elongate-oval; dark reddish black with the head and rostrum black; densely clothed with overlapping ashy-gray and brown scales, the scales discolored by a waxy exudation, the gray scales on head and rostrum; and with strongly clavate semierect, scale-like setae.

Rostrum nearly as long as pronotum, narrower than the head, deeply strigose, carinate only at lateral margins over scrobes; nasal plate prominent, U-shaped, not acuminate at upper limit; a deep median pit at base. Head densely covered with small granular tubercles.

Prothorax nearly one and one-third wider than long, truncate apically and basally; sides evenly arcuate, the pronotum coarsely tuberculate and deeply punctured; a median longitudinal groove present. Scutellum not visible.

Elytra elongate-oval; one and one-half times longer than wide, one and one-fourth times wider than the prothorax, sides subparallel at middle, feebly curved basally, more strongly curved apically; humeri nearly obsolete; base truncate; striae impressed, striae punctures large, round and deep, separated by about one-half their diameter; intervals convex, each with one or more rows of nearly recumbent scale-like setae.

Ventral side and legs clothed as dorsum, the semierect setae more setose and not so strongly clavate on abdominal segments. Anterior and middle tibiae dentate.

Length 5.5 mm., width 2.4 mm.

Male.—Unknown.

Type locality.—Cheyenne, Wyoming.

Distribution.—Known only from the type locality.

Type material.—Holotype (No. 77) and 2 paratypes, Cheyenne, Wyoming, IV-15, in the author's collection. Length of paratypes 5.5–6.0 mm., width 2.3–2.6 mm. The paratypes vary little from the holotype except in size.

This species can be readily distinguished from the others by the prominent clavate suberect setae and the more elongate form. It is the narrowest species in the genus.

Dichoxenus setiger Horn

Figure 2.

Dichoxenus setiger Horn 1876, p. 40. Pierce 1910, p. 348.

Oblong-oval; reddish black to black, densely clothed with large white, brown and grayish black scales which are frequently discolored by a waxy exudation, the lighter scales more promi-

nent on head, rostrum, median and two lateral lines on the prothorax; and with erect very feebly clavate setae.

Rostrum seven-eighths as long as pronotum; deeply, rugosely punctured, strongly channeled forming several irregular carinae; nasal plate large, prominent, elevated, feebly acute at upper end. Head deeply strigose.

Prothorax one and one-fifth wider than long, sides evenly arcuate; pronotum and flanks deeply scarred and rugosely tuberculate; a median longitudinal groove present. Scutellum scarcely visible.

Elytra oval, nearly one and one-half times longer than wide; sides evenly arcuate; base feebly emarginate; humeri nearly obsolete; striae deeply impressed, stria punctures large, deep,



1. *Dichoxenus occidentalis* n. sp., ♀, (holotype).
2. Spermatheca of *D. setiger* Horn.
3. Same of *D. setiger arkansasensis* n. ssp., (holotype).
4. Same of *D. occidentalis* n. sp., (holotype).
5. Diagram of arrangement and structure of elytral setae of *D. setiger arkansasensis* n. ssp., (holotype).
6. Same of *D. setosus* (Blatchley).
7. Spermatheca of *D. tessellatus* n. sp., (holotype).
8. Same of *D. setosus* (Blatchley).

FIGURE 1. Line = 1 mm.

FIGURE 2-8. Line = $\frac{1}{4}$ mm.

and separated by nearly their own diameter; intervals moderately convex, each with a single row of erect feebly clavate setae.

Ventral side and legs clothed as dorsum, the setae more recumbent.

Length 5.3-7.0 mm., width 2.5-3.4 mm.

Type locality.—"Texas".

Distribution.—Texas, Arkansas, Oklahoma and Missouri.

Material examined.—Texas: Tyler, VI-9-04; "Columbus"; Harrison Co., Anderson Co., and Clay Co. Arkansas: Gregory, G. G. Becker; Drew Co., Union Co., and Lafayette Co. Missouri: "Mo.". Oklahoma: Waurika.

Hosts. —Many of the examples from Texas were swept from cotton. Those from Clay Co., Texas and Waurika, Okla. were in river bank trash.

Dichoxenus setiger arkansasensis n. ssp.

Figures 3 and 5

Female.—Oblong-oval; dark reddish black with the head and rostrum black; densely clothed with gray and brown scales which are frequently discolored by a waxy exudation, the lighter scales more prominent on head, rostrum, median and two lateral lines on the prothorax; and with erect, very feebly clavate setae.

Rostrum four-fifths as long as pronotum, narrower than head, finely closely and deeply punctured, the raised areas are small granular tubercles which are often united forming faint striae; nasal plate large prominent, V-shaped. Head densely covered with small granular tubercles, each with an erect seta.

Prothorax one and one-third wider than long, sides evenly arcuate; pronotum and flanks densely covered with small granular tubercles, each with an erect setae, the punctures between tubercles shallow; the median longitudinal groove obsolete. Scutellum not visible.

Elytra oblong-oval, nearly one and one-half times longer than wide; one and one-fourth times wider than prothorax, sides arcuate; base feebly emarginate; humeri feeble; striae moderately impressed, stria punctures large, round and deep, separated by about one-half their diameters; intervals feebly convex, each with a single or double row of erect setae.

Ventral side and legs clothed as dorsum, the erect setae more recumbent. Anterior and middle tibiae dentate within.

Length 6.75 mm., width 3.2 mm.

Male.—Unknown.

Type locality.—Ozark, (Franklin Co.), Arkansas.

Distribution.—Known only from the type locality.

Type material.—Holotype (No. 79) and 3 paratypes all from the same locality in the author's collection. Length of paratypes 5.7–7.5 mm., width 2.7–3.2 mm. The paratypes differ little from the holotype. The dorsum of the rostrum is not so rugose and the median groove of the pronotum is more prominent because of the white scales thereon in each of the paratypes.

The differences pointed out in the key would seem to indicate that *setiger* and *arkansasensis* represent two different species. However the spermatheca of the two forms are nearly identical (figs. 2 and 3). The most easily distinguished difference is the structure of the pronotum in each form, in *setiger* it is rugosely tuberculate, while in *arkansasensis* it is densely covered with small granular tubercles.

Dichoxenus tessellatus n. sp.

Figure 7

Female.—Oblong-oval; reddish brown with the eyes and claws black and the antennae dark reddish brown; densely clothed with brown, tan and white scales, the lighter scales more prominent on head, rostrum, median line and two lateral lines on the prothorax, and in patches on the elytra; and with erect, very feebly clavate setae.

Rostrum nearly as long as the pronotum, narrower than the head, finely closely punctured, tricarinate, the median carina more prominent; nasal plate moderate, V-shaped, feebly acute at upper end. Head densely covered with small granular tubercles, each with an erect seta.

Prothorax nearly one and one-fourth wider than long, sides strongly arcuate; pronotum densely covered with small granular tubercles, each with an erect seta, the flanks a little more rugose; the median longitudinal groove represented only by two shallow foveae. Scutellum very minute, trinagular and densely scaly.

Elytra oval, one and one-half longer than wide, nearly one and one-half wider than prothorax; sides arcuate; base strongly emarginate; humeri nearly obsolete; striae very feeble, stria punctures small, shallow and round, separated by nearly their own diameter; intervals nearly flat, the third, fifth and seventh slightly more convex in basal fourth; each interval with a single row of blunt erect setae.

Ventral side and legs clothed as dorsum, the erect setae sparser and more recumbent. Anterior and middle tibiae dentate within.

Length 7.2 mm., width 3.25 mm.

Male.—Unknown.

Type locality.—Big Spring, (Howard Co.), Texas.

Distribution.—Known only from the type locality.

Type material.—Holotype (No. 78) and 1 paratype, Big Spring, Texas, IX-5-44, in the author's collection.

Hosts.—Both examples were swept from cotton.

This species can be readily separated from all the others by the characters mentioned in the key. The relatively smooth tricarinate rostrum and the complete absence of the waxy exudation covering the scales, which are flat and not overlapping, are distinct. The erect setae are finer, more setose than those of any of the other species.

Dichoxenus setosus (Blatchley)

Figures 6 and 8

Anamelis setosus Blatchley 1916, p. 103.

Dichoxenus setosus (Blatchley), Buchanan 1927, p. 184.

Oblong-oval; dark reddish black to black, densely clothed with dark brown, gray and tan scales; lighter scales more prominent on head, rostrum, median line and two lateral lines on the prothorax; and with erect, feebly clavate setae.

Rostrum nearly seven-eighths as long as pronotum, slightly narrower than the head; densely and rugosely punctured but neither carinate nor channeled except for the deep channel above the scrobes; nasal plate large U-shaped. Head densely and deeply punctured.

Prothorax one and one-fifth wider than long, the sides evenly arcuate; pronotum and flanks densely covered with small granular tubercles, each with a suberect seta. Scutellum scarcely visible.

Elytra oval, one and one-third longer than wide, about one and one-fourth wider than prothorax; sides subparallel at middle, arcuate basally and apically; humeri almost obsolete, base emarginate; striae impressed, stria punctures small, deep and rounded, separated by about one-half their diameter; intervals feebly convex, intervals with one or more rows of erect setae.

Ventral side and legs clothed as dorsum, the erect setae a little more recumbent. Anterior and middle tibiae very feebly dentate within.

Length 6.0–6.5 mm., width 2.7–3.0 mm.

Type locality.—Vigo County, Indiana.

Distribution.—Illinois, Indiana, Missouri and Ohio.

Material examined.—*Illinois*: Pulaski and Massac Counties, "S. Ill.". *Indiana*: Lake, Vigo, and Posey Counties. *Ohio*: Lucas County. *Missouri*: St. Louis.

Hosts.—Swept from *Vernonia fasciculata* Michx. in Indiana. The example from Lucas Co., Ohio was swept from miscellaneous weeds in a clearing in an oak woods.

This species is close to *D. setiger setiger* Horn but that species has the prothorax more rugose, the rostrum more rugosely punctured, and the setae thinner and considerably longer. The spermatheca differ as illustrated in figures 2 and 8.

LITERATURE CITED

- Blatchley, W. S., and C. W. Leng. 1916. Rhynchophora or weevils of N. E. America. The Nature Publishing Company, Indianapolis. 682 p.
- Buchanan, L. L. 1927. Synonymical notes on several Otiorynchid weevils (Coleoptera). Can. Ent. 59: 183–184.
- Horn, G. H. See LeConte, J. L.
- LeConte, J. L. (assis. G. H. Horn.) 1876. The Rhynchophora of America north of Mexico. Proc. Amer. Phil. Soc. 15: 1–455.
- , and G. H. Horn. 1883. Classification of the Coleoptera of North America. Smithsonian Misc. Coll. 26(507): 1–567.
- Pierce, W. D. 1910. Studies of North American weevils. Proc. U. S. National Mus. 37: 325–364.
- . 1913. Miscellaneous contributions to the knowledge of the weevils of the families Attelabidae and Brachyrhinidae. Proc. U. S. National Mus. 45: 365–426.
- Schenkling, S., and G. A. K. Marshall. 1931. Curculionidae, Leptopinae. Coleopterorum Catalogus 28, par 114: 1–83. Berlin. W. Junk Publishers.

FACTORS INFLUENCING ELECTRICAL PROPERTIES OF WHOLE SMALL ANIMAL BODIES

TAMMADON FARZANEH AND RALPH W. STACY

*Division of Biophysics, Department of Physiology, College of Medicine,
The Ohio State University, Columbus 10*

There are several indications that the measurement of electrical impedances of whole animal bodies might provide useful information concerning the physiological state of the animal, particularly with regard to the water and electrolyte content of the tissues. Such measurements have been used as a diagnostic tool in the study of thyroid disease, (Brazier, 1933; Barnett, 1937; Krepsky, 1950, for example.

Unfortunately, most of the studies to date have been made on the human body, and there has been very little opportunity for study of the physical and physiological factors contributing to variations in these properties. The work to be described herein was done preliminary to making a series of measurements for the determination of the influence of endocrine factors on the electrical properties of the body.

It is apparent that the use of small animals for these studies would make possible studies on ablation of endocrine organs, injection of hormones, etc. Such studies are difficult to perform on humans. Also, such experiments can be performed in much larger numbers on small animals, so that statistical variations can be dealt with. For several reasons, it was decided to make these measurements on white rats.

In order to achieve useful analyses of data obtained in subsequent experimental procedures, it was necessary to know the effect of the following on the measurements:

Physical factors:

1. Type and size of contact electrode.
2. Salt concentration of contact material.
3. Temperature of the contact electrode.
4. Frequency of alternation of the applied electrical voltages.
5. Magnitude of the applied voltages.

Physiological factors:

1. Weight and age of the animal.
2. Effects of repeated measurements.
3. Effects of Adrenaline.
4. Effects of anesthesia.

METHODS AND PROCEDURES

Measurement techniques.—In order to make the measurements as uniform as possible, it was necessary to immobilize the animal on a special rat board constructed for the purpose. On either side of the board were two stainless steel plates so arranged that the paws of the animal could be conveniently placed in contact with the plates. The paws of the animal were scrubbed thoroughly and were bound to the contact plates by gauze strips soaked in saline solution. The salt concentration of the solutions used were varied as one of the experimental procedures to be described later.

In our early experiments, the measurements were made with a General Radio Co. impedance bridge, type 650A, using a microphone hummer at 1000 cps. as the source of current and a telephone receiver as the detector. This method was in accordance with that used in much of the earlier literature.

Since this setup was very much limited in its variability, the system was

modified to the use of a Schering bridge (modified Wheatstone) using an audio oscillator as the source of current and a cathode ray oscilloscope as the detector. Such an arrangement does provide more flexibility than the other setup but still requires considerable effort to compute the final values. Finally, we assembled and tested a system using an ammeter-voltmeter arrangement and measuring the phase angle between voltage and current with a commercial phasemeter. This last arrangement was found to be quite as accurate as the other methods, and was much easier to use.

The scheme thus finally settled on is shown in figure 1. The current source is a Hewlett-Packard Model 200B audio oscillator. The resistances used were two Leeds and Northrup decade resistance boxes (1 to 1000 ohms), and the capacitance was a decade capacitor, Leeds and Northrup, 0.001 to 10 microfarad. The voltmeters used were two Ballantine Model 310 electronic AC voltmeters. The phase angle measurements were made with a Technology Instrument Co. Type 320AB phase angle meter. This latter meter provides for direct readings of phase angle without ambiguity on a meter which has full scale ranges of 360°, 180°, 90°, and 36°. In addition, 180° phase reversing switches for each channel are provided, making possible "expanded scale" operation for measurement of small changes in any of four quadrants.

In use, the output of the audio oscillator was adjusted to 10 volts. The system was then switched into the measuring condition, and the resistance was varied until the two voltmeters read identical values (*i.e.*, 5 volts each). The value of the resistance is recorded as the impedance of the tissue. The phase angle is read directly from the meter. A check on the phasemeter operation was made with each series of measurements, by switching to the check condition and putting in known values of capacitance and resistance. The theoretical phase angles were computed from the relation:

$$\tan \phi = \frac{I_R}{I_C} = \frac{R_1}{X}$$

where ϕ is the impedance angle of the physical model, I_R is the current through the pure resistance, I_C is the current through the resistance-reactance combination, R_1 is the value of the pure resistance at balance, and X is the reactance of the physical model. Actually, the phasemeter measures θ , which is the supplement of ϕ .

Experimental procedures.—Our first item of concern in this series of experiments was the determination of variation of impedance and phase angle with frequency of alternation of applied voltage. For this study, 8 normal, adult rats were anesthetized with Evipal sodium (10 mg./100 gm. body weight, intraperitoneally) and placed on the board. The saline used was 1 percent NaCl. Impedance and phase angle values were obtained at 10 cps. intervals to 100 cps., at 100 cps. intervals to 1000 cps., and at 1000 cps. intervals to 20,000 cps. A few measurements at higher frequencies were made.

On the same series of animals, measurements were made at frequencies of 1000 cps., 5000 cps., and 15,000 cps. with voltages such that the applied voltages were 1, 2, 4, 6, 8, and 10 volts.

A series of measurements were made on 5 animals, in which the electrodes used were 60, 120, and 240 cm² in area. Full frequency spectra were determined in each case.

Another series of 5 animals were measured with the 120 cm² electrodes (used in all other experiments, incidentally) in which the saline concentration was varied to give 0.5%, 1%, 5%, and 10% NaCl. Again, full frequency spectra were determined in each case.

The measurements were repeated on these same animals with variation of the temperature of the saline solution applied to the electrodes such that the temperatures were 18°, 23°, and 28° C.

Determinations of the effects of anesthesia on the values obtained were made on three normal animals. These animals were used to being handled, and were tied down to the rat board and their electrical impedance characteristics measured without anesthesia. Each rat then was injected intraperitoneally with Evipal and as soon as anesthesia was surgically complete (using the ordinary signs) the measurements were repeated.

To determine the effect of age and weight of the animals on the findings, a group of 11 male and 12 female rats were selected at random from our rat colony, anesthetized, and full frequency spectra were determined on each.

In a group of 4 animals, complete frequency spectra were determined in the usual way. Then, each animal was given a dose of Epinephrine and rapid determinations made at 100, 1000, and 10,000 cps. at 1 min., 5 min., and 20 min. intervals. A second group of animals was subjected to similar experimentation,

TABLE 1
Variation of Impedance (Z) and Phase Angle (θ) with Anesthesia

		Before Anesthesia	After Anesthesia	Difference
Z (ohms)	10KC	2967	2600	-367 ± 32 (-12.4%)
	15KC	2617	2430	-187 ± 23 (-7.1%)
	20KC	2533	2390	-143 ± 14 (-5.6%)
θ (degrees)	10KC	14.3	15.2	$+0.9 \pm .04$
	15KC	13.0	13.75	$+0.75 \pm .04$
	20KC	11.75	12.42	$+0.67 \pm .02$

TABLE 2
Variation of Impedance (Z) and Phase Angle (θ) with Weight of Animals

Weight (gms)	Z (ohms)	θ (degrees)
120-129	2543 ± 16	16.67 ± 1.04
130-139	2140 ± 17	$16.25 \pm .04$
140-149	2253 ± 135	16.1 ± 1.3
150-159	2377 ± 76	$13.08 \pm .12$
160-169	2440 ± 54	12.9 ± 0.6
170-179	2085 ± 87	12.0 ± 0.4

except that the Epinephrine concentration was higher. This was repeated until four groups were studied, with epinephrine concentrations running from physiological doses to massive pharmacological doses.

Lastly, in a group of 8 animals (3 female and 5 male) measurements were made on successive days for a two week period. These measurements were compared to determine the effect of repeated measurement.

RESULTS

The individual data obtained in these experiments comprise a voluminous mass of information bits too extensive for rapid comprehension. Therefore, the data to follow are averaged for each group of animals and for each experimental procedure. Where such information is available and applicable, the average value will be followed by the standard error of the mean.

The average data on the first group of animals (the determination of the effects of frequency) are presented graphically in figure 2. Impedance is plotted on the vertical scale at the left of the figure, and phase angle on the right. It will be noted that the impedance is maximal at low frequencies (22,000 ohms at cps or less), and is reduced in the familiar X_c manner with increase in frequency. The impedance is minimal for all practical purposes above about 10,000 cps.

The phase angle plot indicates a maximum phase angle of about 53° at 200 cps. The phase angle drops off at higher frequencies, but not so rapidly as does the impedance. Above 50,000 cycles, the phase angle drops off precipitously, but it should be noted that these frequencies are greater than the frequency response rating of the phase meter, and therefore may not be of significance.

The spread of values in these frequency measurements was relatively large, but every individual spectral curve followed closely the contours of the average curve.

In the determinations of the effects of voltage applied on the measurements, it was found that impedance values were the same at all applied voltages. How-

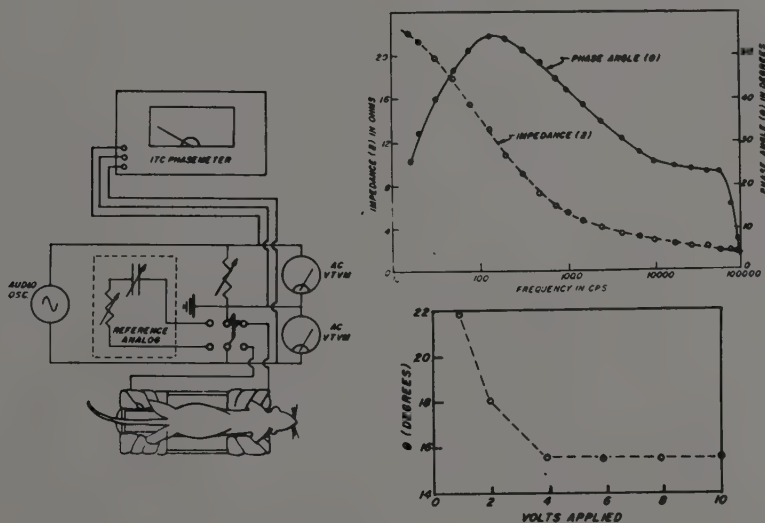


FIGURE 1 (left). Apparatus arrangement for measurement of electrical impedance properties of white rats.

FIGURE 2 (upper right). Variation of electrical impedance characteristics of white rats with frequency.

FIGURE 3 (lower right). Variation of impedance phase angle with applied voltage.

ever, the phase angle indicated on the phase meter varied as shown in figure 3. For reasons to be listed in the discussion, it is believed that this variation is a function of the phase meter, and not of tissue properties. It is apparent that at voltages of 5 volts or greater, no variation is to be expected.

There were no differences noted in the impedance and phase angle values obtained when the electrode areas were 60, 120, and 240 cm^2 . Since the 120 cm^2 electrodes were of a convenient size, they were used in all subsequent measurements.

Also there were no significant differences noted when the solutions used to soak the gauze wrappings were changed in concentration from 0.5 to 10 percent

NaCl. Thus, it is indicated that the contact resistance so obtained is minimal, and that our measurements are actually those of electrical properties of tissues. The same lack of effect was noted when the gauze packs were saturated with saline solutions of different temperatures.

The data showing the effect of anesthesia on the values obtained is given in table 1. Since differences at very low frequencies were negligible, only those values at 10,000 cps and higher are given. The difference was maximal at 10,000 cps. The impedance differences noted are definitely greater than the error of the measuring instruments, and the phase angle measurements are such that the differences are considered significant. The accuracy of the phase angle meter is generally considered to be 0.5° in the range in which these measurements fall.

The measurements of variations of impedance and phase angle with size of the animal are shown in table 2. It is seen that there is no consistent pattern of variation of the impedance (measured at 10,000 cps) with size, but the phase angle showed a progressive diminution from 16.7° to 12° as the size and age of the animal increases. The number of animals falling in each size group is relatively small, so that the standard errors are large. However, the diminution of phase angle is so consistent that there is not overlap in any of the groups.

In passing, it was noted that by far the greater variability in phase angle and impedance was seen in the female rats. This later was traced to a cyclic variation with the estrous cycle (to be described in a subsequent publication).

In the last group of animals, no significant differences were noted with several successive daily determinations of impedance and phase angle in the male rats. In the females, the cyclic variations did not appear because the estrous cycle was stopped completely after the first two or three days, and the females behaved in the same manner as the males, showing little or no variability from day to day.

DISCUSSION

The use of small animals for impedance studies.—These experiments demonstrate beyond doubt that significant studies of factors varying the electrical impedance properties of the whole body can indeed be performed on small animals. This should make it possible to devise experimentation with biological procedures which are impossible of accomplishment with man or larger mammals. An example of this will be given in the paper to follow.

In this case, the impedance one measures is that of the deep tissues plus two layers of skin. In view of the success various workers have experienced in making measurements of deep tissue impedance by using several electrodes (Horton and Ravenswaag, 1935) there is no reason why such an arrangement cannot be used with rats. It may be that these isolating arrangements may provide more useful data biologically.

The method used in measurement of impedance properties.—It is apparent from this work and that of others that the impedance alone is not enough for intelligent analysis of the electrical properties of the whole body; the impedance phase angle is more constant than the impedance magnitude and seems to show more variation with physiological manipulation. The method used in these studies (*i.e.*, the use of a phase meter with the voltmeter-ammeter combination) is very much easier to use than the methods formerly applied. The errors involved are perhaps a little larger than when one computes the phase angles by the long method. However, these errors are small compared with the usual biological variation. Therefore, it would seem that such errors are not significant enough to warrant eliminating the method.

Physical factors influencing the measurements.—Both the impedance magnitude and the phase angle are more susceptible to physiological changes in the middle of the frequency range covered in these experiments. Therefore, it would seem that approximately 10,000 cycles per second is the proper frequency for

making physiological studies. In some cases, one might wish to determine the entire frequency spectrum, since this can be done with little difficulty by the voltmeter-ammeter method. If, on the other hand, one wishes to follow changes which occur within seconds or a very few minutes, one can make repeated measurements at a single frequency and obtain meaningful information.

It is fortunate that the measurements are not appreciably affected by electrode size greater than our minimum, the concentration of salt in the soaking solution, or the temperature of the soaking solution. All of these observations mean in the long run that with the preparations and solutions and contact method used, the skin to electrode impedance is minimal and is not greatly influencing the results.

The constancy of the impedance values with magnitude of applied voltage is entirely to be expected in the range of voltages used here, for within this range the tissues are linear components for all practical purposes. At very high applied voltages, it is likely that such linearity would not hold, and the impedance values would be different. The phase angle values do change up to about 4 volts in our system, and we believe this is due to voltage dependence of the phasemeter response at low applied voltages. The manufacturer's specifications indicate that the phasemeter should work properly at 1 volt input, but this has not been true in our experience. At the frequencies which are apparently useful to us, the voltage magnitude is not too important from the standpoint of its biological effects, since stimulation of the biological tissues will not occur at such frequencies. In the anesthetized animals, even the low frequency currents seemed to produce no undesirable effects.

The influence of biological factors.—The biological factors influencing our measurements are probably much more important than any others in designing reproducible and interpretable experiments. The fact that even large doses of epinephrine do not produce significant changes in the impedance phenomena is a fortunate one, since such possible changes would complicate the interpretation of data annoyingly. The handling of animals preparatory to making the measurements or even to anesthesia certainly produces significant quantities of epinephrine in the circulation, and if this had significant effects, one would have to design his experiments much more carefully.

The comparatively small changes associated with anesthetization are nevertheless statistically significant and meaningful. It is most likely that the decrease in impedance magnitude which occurs when the animals are anesthetized is caused by a change in the volume of blood contained in the tissues contributing to the impedance. The blood impedance is less than that of the other tissues. Again, however, the changes associated with anesthetization are small, and so long as one makes sure that all the animals in an experiment are treated similarly in this respect, there is no reason that this would be a complicating factor.

The relative constancy of readings in male rats and in females after the first two or three days of a series of daily measurements also makes the interpretation of changes associated with physiological manipulation easier. From data to be described in subsequent experiments, it has been established that most of the variations noted with female rats measured repeatedly are associated with changes of physiological condition of the tissues during the estrous cycle. Repeated measurements on the same animal invariably bring about a complete cessation of the estrous cycle, as evidenced by vaginal smear studies, and this disappearance adequately accounts for the changes noted in impedance and phase angle values on daily repetition of measurement.

Lastly, the physical significance of phase angle measurements lies in the relationship of resistance to capacitive reactance, in the absence of inductive properties. Most analyses of the basic mechanisms involved in the production of a capacitive reactance in living material bear strongly on the role of dipole

orientation (Debye, 1929; Fröhlich, 1949). In view of the major water shifts which are known to occur in a number of physiological conditions, there is every reason to believe that electrical property measurements may prove of value in making physiological studies.

SUMMARY

Studies have been made of the physical and physiological factors which determine the impedance and phase angle of the whole bodies of laboratory rats. These measurements have been made with a voltmeter-ammeter method, determining the phase angle with a commercial phase angle meter.

The technique used has proved to be sufficiently accurate and much easier to use than previous bridge techniques.

It is demonstrated that it is quite feasible to make such measurements on small laboratory animals, and the advantages of being able to make major physiological changes and work in large numbers renders such measurement valuable.

Within the practical ranges used, electrode size and contact solution salt concentration do not effect the results. Epinephrine also does not have an appreciable effect, so that excitement would not influence the results. Anesthetization produces a small, quite reproducible reduction in impedance and a similar increase in phase angle. It was found that there is not consistent impedance variation with animal size, but that the phase angle was reduced progressively with increased size of the animal.

Daily determinations on a single group of rats indicates that female rats show a variability associated with the estrous cycle. Repeated measurements bring about a cessation of the estrous cycle, and these females as well as males give consistent results on subsequent measurements.

REFERENCES

- Barnett, A. 1937. The basic factors involved in proposed electrical methods for measuring thyroid function. *Western Jour. Surg. Obst. and Gyn.* 45: 322-326.
- Brazier, M. A. B. 1933. An electrical method for use in the diagnosis of diseases of the thyroid gland. *Lancet* 225: 742-744.
- Debye, P. 1929. Polar molecules. The Chemical Catalogue Company, Inc., New York.
- Fröhlich, H. 1949. Theory of dielectrics. The Clarendon Press, Oxford.
- Horton, J. W., and A. C. Van Ravenswaag. 1935. The electrical impedance of the human body. *Franklin Inst. Jour.* 220: 557-561.
- Krepesky, M. 1950. The impedance Angle and thyroid dysfunction. *Am. Jour. Med. Tech.* 16: 267-275.

Fundamental Formulas of Physics. Donald H. Menzel, Editor. Prentice-Hall, Inc., New York, 1955. xxxv+765 pp. \$10.65.

This book is meant to be a comprehensive reference book on the fundamental formulas of mathematical physics. Material from such border fields as mathematics, chemistry, astronomy, meteorology, biology and electronics is also included.

The book is divided into thirty-one chapters. Each chapter is a unit in itself and covers a particular branch of physics or an allied field. The chapters are arranged in an orderly sequence beginning with "Basic Mathematical Formulas" and progressing through mathematics, physics and other border fields. Each chapter is written by one or two persons who are among the foremost authorities in their particular field. While the styles and modes of presentation vary in that some authors merely list the basic formulas while others have added appreciable explanatory text, the overall effect is most satisfactory.

There is enough explanatory text in the places where most needed to make the book much more than the title might imply. It is much more than a handbook of formulas. The book can serve as a guide for research, as an aid in reviewing a familiar field, or for gaining an insight into a new field.

FRED P. DICKEY.

VOCAL GYMNASTICS IN WOOD THRUSH SONGS

DONALD J. BORROR AND CARL R. REESE¹

Department of Zoology and Entomology, The Ohio State University, Columbus 10

The songs of the wood thrush (*Hylocichla mustelina*) have often been described as being among our most beautiful bird songs; they are quite musical, and the notes are sometimes said to have a flute-like quality. In an attempt to learn something of the detailed character of wood thrush songs, and possibly to learn why their quality is so remarkable, we have made audiospectrographs of most of the wood thrush songs in our recordings. The graphs indicate that most of these songs contain some very complex elements, which would seem to call for some rather remarkable vocal gymnastics by the bird.

Most wood thrush songs² consist of three parts. The first part consists of from two to six low weak notes, which are often not heard unless the bird is fairly close. The second part consists of much louder notes which are usually clear, musical, and somewhat flute-like in quality; this is the most distinctly heard portion of the song. The third part consists of notes that are generally uttered too rapidly for the ear to accurately determine their character; they are often relatively low or high in pitch, and are sometimes rather weak. Occasionally the first part of the song, or the first and third parts, may be lacking.

An individual wood thrush usually has two or three different variations of the first part of its song, and several variations of the other two parts. These different part types are variously combined to form a number of different song patterns. The songs are usually sung about every three or four seconds, and successive songs are nearly always different. A bird apparently does not sing its different song patterns in any definite sequence.

We have recordings of 25 different wood thrushes, and no two of these contain identical songs. There are several cases in these recordings where the first parts of the songs of different birds are identical, but no cases of identical second or third parts in the songs of different birds; in many cases the second or third parts of the songs of different birds are very similar, but not identical. It would therefore appear, as Saunders has repeatedly pointed out (1921, 1924, 1935, 1948), that it is possible to recognize an individual wood thrush by its songs.

THE SONGS OF ONE WOOD THRUSH

We can best illustrate "vocal gymnastics" in the wood thrush by a consideration of the songs of one bird, of which we have 55 recorded songs. The recording was made with a Magnemite Model 610-E tape recorder in Blendon Woods, Franklin County, Ohio, July 2, 1954, by the senior author, and is No. 1175 in the library of bird recordings of the Department of Zoology and Entomology, Ohio State University.

Our 55 recorded songs of this bird show two variations of the first part of the song, five of the second part, and nine of the third part. These songs contain 13 principal patterns, or, taking into account the variations of the first part of the song, 18 patterns. The two variations of the first part of the song are extremely similar, and two songs differing only in the first part would be difficult or impossible to distinguish by ear. This number of patterns (18) is nowhere near the

¹This study has been supported by grants from The Ohio State University Development Fund, and the Graduate School of The Ohio State University. Mrs. Mary Jane Alluisi assisted in the preparation of the audiospectrographs.

²We use the term "song" for a group of notes that lasts a second or two; some writers term these note groups "phrases" of the wood thrush's song.

90 that the bird *might* sing, but it is quite likely that had we recorded more songs of this bird we would have found more song patterns. The number of times each pattern is represented in the 55 songs is shown in table 1. The bird did not sing its different songs in any particular sequence, but some (e.g., pattern 1A) were sung more often than others.

Variations in the First Part of the Song.—The first part of the songs of this

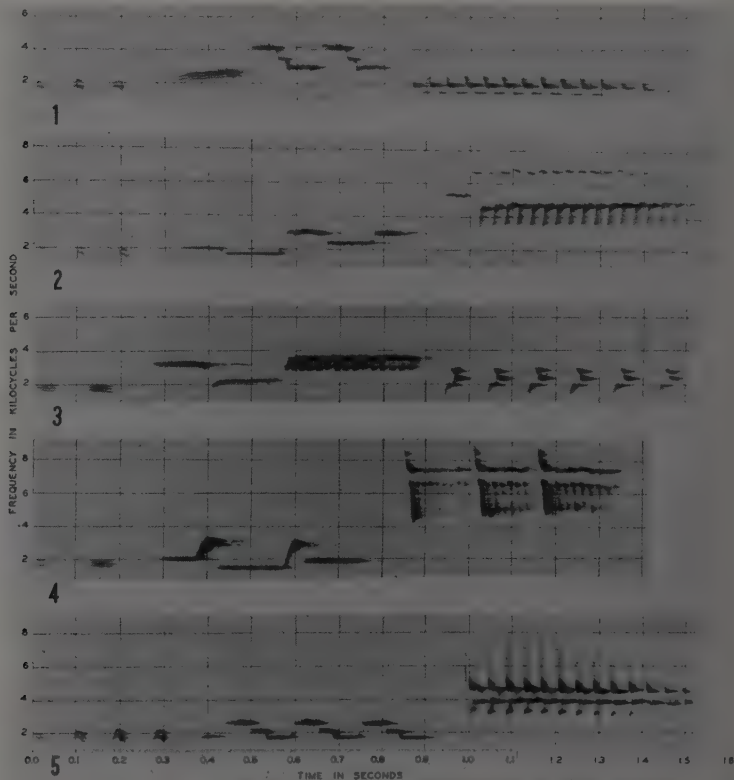


PLATE I. Vibralyzer graphs of wood thrush songs, from recording No. 1175, Franklin Co., Ohio, July 2, 1954. FIGURE 1, the sixth song in the recording, pattern 1A. FIGURE 2, the fourth song in the recording, pattern 3A. FIGURE 3, the eighth song in the recording, pattern 4B. FIGURE 4, the thirty-fifth song in the recording, pattern 5B. FIGURE 5, the second song in the recording, pattern 6A.

bird contain from two to six very weak notes, and the notes are of two types that may be designated as A and B. The notes of type A (e.g., fig. 6, the first 0.2 sec.) are about 0.025 second in length and are uttered at the rate of 14 per second; they are pitched at approximately the third G sharp above middle C. The notes of type B (fig. 3, the first 0.2 sec.) are about 0.05 second in length and are uttered at the rate of about 7 per second; their pitch is about the same as the notes of type A, but actually it fluctuates up and down about 200 times a

second. Type A notes occur in 47 of the 55 songs (13 of the 18 patterns), and type B notes occur in the other 8 songs.

Variations in the Second Part of the Song. The five variations of the second part of the songs of this bird may be designated by the letters A-E. Type A (fig. 1, 0.3 to 0.8 sec.) consists of a low buzzy note followed by two groups of notes of three notes each. The buzzy quality of the first note is due to the fact that

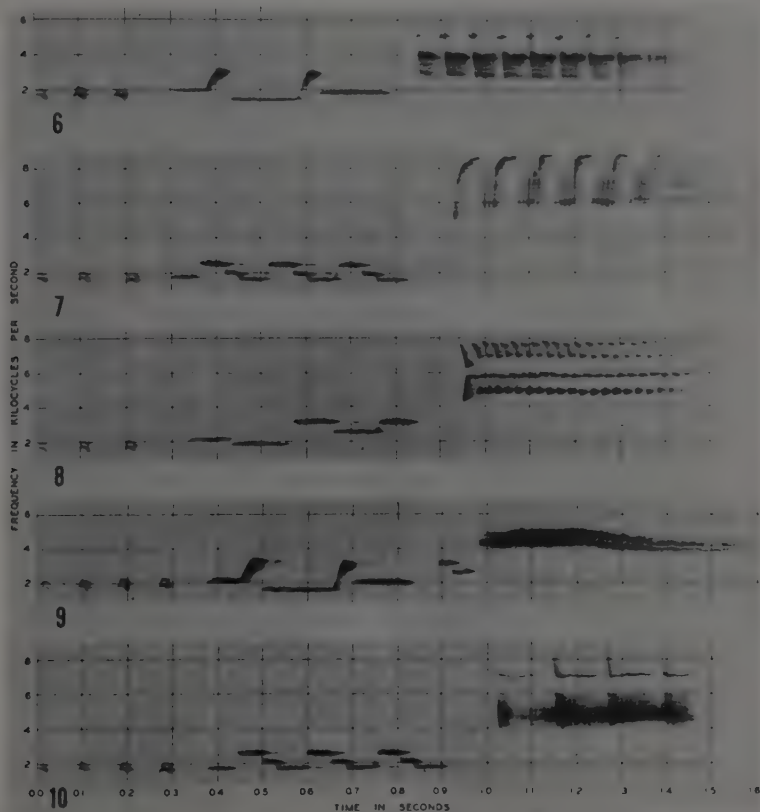


PLATE II. Vibralyzer graphs of wood thrush songs, from recording No. 1175, Franklin Co., Ohio, July 2, 1954. FIGURE 6, the twelfth song in the recording, pattern 7A. FIGURE 7, the fifth song in the recording, pattern 9A. FIGURE 8, the eleventh song in the recording, pattern 10A. FIGURE 9, the seventeenth song in the recording, pattern 11A. FIGURE 10, the nineteenth song in the recording, pattern 12A.

the pitch of this note fluctuates up and down 160 times a second. The notes in the two groups of three are pitched at C, A, and F sharp in the top octave of the piano range. Type B (fig. 2, 0.35 to 0.9 sec., and fig. 8) consists of five loud clear notes, pitched at C sharp, B, G, E, and G; the C sharp is three octaves above middle C. Type C (fig. 3, 0.26 to 0.9 sec.) consists of two loud clear notes followed by a trill; the first two notes are pitched at G sharp and D, the third above middle C; the trill is a single note that fluctuates in pitch 50 times a second, be-

tween the fourth G and A sharp above middle C. Type D (fig. 4, 0.3 to 0.76 sec., and fig. 6 and 8) consists of three loud clear notes, the first two of which are abruptly upslurred at the end. The first note is pitched at the third C above middle C, and at the end slurs up to G sharp; the second note is pitched at the F sharp below this C, and at the end it slurs up to the next G; the third note is pitched at C, the same as the principal part of the first note. Type E (fig. 5, 0.39 to 0.91 sec., and fig. 7 and 10) contains ten loud clear notes, the last nine in three groups of three each; the notes in each group are pitched at E, C, and A, three octaves above middle C.

Saunders (1924, 1935) states that the second part of the song of the wood thrush usually contains two to five notes, but that he has heard one with seven notes. Of the five second-part types in the songs of the Blendon Woods bird,

TABLE 1

Analysis and Summary of the Songs of a Wood Thrush Recorded in Franklin County, July 2, 1964 (Recording No. 1175)

Song Pattern	Analysis of Song Pattern			Number of Songs in Recording	Figure
	Type of Part 1	Type of Part 2	Type of Part 3		
1A	A	A	A	9	1
2A	A	A	B	2	—
3A	A	B	C	4	2
3B	B	B	C	2	—
4A	A	C	D	3	—
4B	B	C	D	2	3
5A	A	D	B	2	—
5B	B	D	B	2	4
6A	A	E	E	5	5
7A	A	D	F	3	6
8A	A	C	G	2	—
9A	A	E	G	4	7
10A	A	B	H	5	8
10B	B	B	H	1	—
11A	A	D	I	3	9
11B	B	D	I	1	—
12A	A	E	B	4	10
13A	A	C	B	1	—

two (C and D) contain three notes, one (B) contains five, one (A) contains seven, and one (E) contains ten. We have recordings of other wood thrushes in which the second part of the song contains more than seven notes.

The frequency with which the five variations of the second part of the song occur in the 55 songs of this bird is shown in table 1.

Variations in the Third Part of the Song.—This is the most variable part of the song, though some of the variations sound very similar to the ear. The nine variations of this part found in the 55 songs may be designated by the letters A-I, and the frequency of their occurrence is shown in table 1. The notes in this part are generally short and are uttered very rapidly; they are usually relatively low-pitched or high-pitched, and are sometimes quite weak. The most remarkable "vocal gymnastics" in wood thrush songs occur in this part of the song.

Type A (fig. 1, 0.9 to 1.5 sec.) contains 13 to 15 pairs of low notes, pitched at the third F and A sharp above middle C; the song shown in figure 1 contains 13 pairs of notes in this part. Type B (fig. 4, from 0.85 sec. to the end of the song,

and fig. 10) is unusual in consisting of two series of notes uttered simultaneously; it contains three to five high-pitched notes that are relatively steady in pitch (at about the first B above the upper limit of the piano range) following an abruptly down-slurred element at the beginning of each note, and at the same time a rapid series of abruptly down-slurred notes uttered at the rate of 65 (fig. 4) to 105 (fig. 10) a second. The lower notes are slurred from about A to D sharp, in the first octave above the piano range, and this slurring takes place in about 0.01 second. Type C (fig. 2, 0.94 sec. to the end of the song) consists of a single steady note followed by 13 to 18 pairs of notes of alternating pitch; the first note is pitched at the first F above the upper limit of the piano, and the notes of the following pairs are pitched at about the A and D sharp above the upper limit of the piano. These note pairs are uttered at the rate of 34 pairs per second. The lower note of each pair begins with a rapidly up-slurred element. Type D (fig. 3, 0.95 sec. to the end of the song) consists of five or six groups of two low notes each, uttered at the rate of 10 groups a second; each group consists of a low note, pitched at the third C above middle C, followed by a note that slurs downward from the F sharp to the D sharp above this C. Type E (fig. 5, 1.0 to 1.5 sec.) consists of 13 to 15 pairs of notes uttered at the rate of 25 pairs per second; the notes of each pair are uttered simultaneously, the upper note beginning with a rapidly down-slurred, element, and the lower note beginning with an up-slurred element. The up-slurring of the lower note begins immediately after the down-slurred part of the higher note. The louder parts of these two notes are pitched at the first D above the upper limit of the piano, and the B below this D. Type F (fig. 6, 0.85 sec. to the end of the song) consists of eight or nine groups of very short, rapidly down-slurred notes; the notes in each group are uttered at the rate of 120 per second, and the groups at the rate of 16 per second. The first note in each group is down-slurred over a greater range than the remaining notes of the group, from the first E above the piano range down to the F nearly an octave below; this slurring takes place in 0.005 second. Type G (fig. 7, 0.93 sec. to the end of the song) consists of eight or nine groups of very short, weak, and rapidly up-slurred notes; the notes in each group uttered at the rate of 90 per second, the groups at the rate of 12 per second. The last note in most of these groups goes up a little higher in pitch than the others, to about the second C sharp above the highest note on the piano. Type H (fig. 8, 0.95 sec. to the end of the song) is rather unusual, and consists of two simultaneously uttered notes, one about five or six half-notes on the musical scale above the other, each fluctuating up and down in pitch 45 times a second. Type I (fig. 9, 0.9 to 1.6 sec.) consists of two short notes followed by a buzz; the two short notes are pitched at G and E in the top octave of the piano range; the buzz is a note that fluctuates up and down in pitch, over about three half-notes on the musical scale, 140 times a second.

Pitch Range.—Brand (1938) gives the range of the songs of the wood thrush as 1825–4025 cycles per second; this is from about the third A sharp above middle C to the fourth C above middle C (the fourth C above middle C, which is the top note on the piano, has a frequency of 4096 cycles per second), or a range of about 14 musical intervals. The pitch range in the Blendon Woods bird varied in different song patterns, from about an octave in pattern 4B (fig. 3) to nearly two and one-half octaves in pattern 9A (fig. 7). The range of this bird, as indicated by our graphs, was from about 1640 to 8900 cycles per second, or from about the third G sharp above middle C to the second C sharp above the upper limit of the piano range (27 musical intervals).

VOCAL GYMNASTICS

What we may call "vocal gymnastics" in the wood thrush includes the following features:

- (1) Many notes, particularly in the second part of the song, are so pitched

that they follow our musical scale very accurately, thus giving a musical character to the song.

(2) There is some overlapping of the notes, with one note beginning before the preceding note ends, which results in the bird uttering more than one note at a time. In one song that we have recorded (another bird in Franklin County, Ohio) there is a moment of about 0.1 second in length when four notes are uttered simultaneously.

(3) The songs frequently contain notes in which the pitch fluctuates up and down very rapidly, as fast as 200 times a second; some songs contain two fluctuating notes uttered simultaneously.

(4) The third part of the song sometimes consists of a series of relatively steady notes, and at the same time a rapid series of abruptly down-slurred notes.

(5) Some notes are slurred over nearly an octave in 0.005 second.

LITERATURE CITED

- Brand, A. R. 1938. Vibration frequencies of passerine bird song. *Auk*, 55: 263-268.
 Saunders, A. A. 1921. The song periods of individual birds. *Auk*, 38: 283-284.
 ———. 1924. Recognizing individual birds by song. *Auk*, 41: 242-259; 2 fig.
 ———. 1935. A guide to bird songs. D. Appleton-Century Co., Inc., New York. xvii+285 p., 163 fig.
 ———. 1948. The seasons of bird song—the cessation of song after the nesting season. *Auk*, 65: 19-30; 2 fig.

Niels Bohr and the Development of Physics. *W. Pauli*, Editor. McGraw-Hill Book Company, Inc., New York. 1955. vii+195 pp. \$4.50.

This is not a conventional *Festschrift*, but rather a series of essays dedicated to Bohr on the occasion of his seventieth birthday. The list of contributors reads like an international "Who's Who" in modern physics: C. G. Darwin, Heisenberg, Pauli, Landau, Rosenfeld, O. Klein, Casimir, F. L. Friedman, V. F. Weiskopf, J. A. Wheeler, and J. Linhard. Most of the articles are highly erudite and up-to-date discussions of various aspects of such portions of atomic and nuclear physics as Niels Bohr has been himself concerned with during his long and productive life. In some of the contributions, such as that of Landau (of Moscow), new and previously unpublished results have been included. As a result, the book will be of interest primarily to theoretical physicists, and possibly to historians of science.

Very little biographical material about Bohr the man has been included, which is a pity. The occasion is clearly a sentimental one, and could have provided an excellent opportunity for a more personalized evaluation.

CHARLES SÜSSKIND.

The Invertebrates. Volume IV. Echinodermata. *Libbie H. Hyman*. McGraw-Hill Book Company, Inc., New York. 1955. vii+763 pp. \$10.00.

In the fourth volume of her monumental series, Dr. Hyman deals exclusively with the echinoderms. As in previous volumes, the first of which appeared in 1940 and the third in 1951, her aim is to survey and critically analyze existing knowledge of anatomy, classification and life history. This aim is admirably accomplished, insofar as it is possible to do so in a single volume. In addition, unlike in the three previous volumes, she devotes considerable space to the discussion of geographic distribution. The several exclusively fossil classes of echinoderms are described only briefly, and most attention is paid to existing classes. The discussion of each existing class is full, detailed, and well illustrated.

The book will mainly be useful as a reference for teachers and students. The final chapter, however, deals with phylogeny within the phylum, and certainly should be assigned reading in many courses concerned with evolution. Discussion of the relationships of the echinoderms to other phyla is deferred until further volumes of the series, dealing with these phyla, have appeared.

CHARLES C. DAVIS.

STUDIES ON MARINE BRYOZOA. VII. *HIPPOTHOA*

MARY D. ROGICK

College of New Rochelle, New Rochelle, New York

The writer wishes to express her very deep appreciation to the National Science Foundation for research grants which have made this and other studies possible, and to the U. S. National Museum, Smithsonian Institution, for the loan of bryozoans collected by Comdr. David C. Nutt during the U. S. Navy's 1947-48 Antarctic Expedition.

The purpose of the present study is to: 1, report two *Hippothoa* species from new Antarctic localities; 2, draw attention to the range of variation in time, geography and morphology exhibited by these Hippothoidae; and 3, set forth some problems as affinities, identification and possible protandry which came to light in these specimens.

SPECIAL PROBLEMS

An examination of the present collection's *Hippothoa bougainvillei* showed it to be a species which exhibited considerable variation in general appearance. It is closely allied to *Hippothoa hyalina*, a very widely distributed, common and cosmopolitan species. In fact, some authors have considered them as one species. Some of the less rugose *bougainvillei* colonies (fig. 4) are almost indistinguishable from *H. hyalina*, while its spiny colonies (fig. 5) are readily identifiable as a distinct species. Still other *bougainvillei* colonies whose zooids are greatly crowded can resemble another genus altogether (*Cellepora*). That they are not three distinct species or varieties can be ascertained by finding intergrading types of zoids within the same colony or from the same station.

One unexpected difficulty came to light. *Hippothoa hyalina* with which *H. bougainvillei* is most likely to be confused, although often reported in the past, has not yet been studied truly critically as regards variations, measurements and behavior under different ecological and substrate conditions. Canu and Bassler (1923, p. 94) stated that *H. hyalina* proper "is a species of the cold boreal zone and never goes farther south than the 42nd parallel." As matters stand at present, *H. hyalina*, if all who reported it were dealing with the one and same species, is presumably world-wide in distribution, while *H. bougainvillei* is to date known only from the lower half of the southern hemisphere. Moreover, *H. hyalina* has a geological range from the Pleistocene to the present (Canu and Bassler, 1923). *Hippothoa bougainvillei*, the present-day species, is apparently very closely related, if not identical, with the Pheistocene *Hippothoa hyalina* var. *rugosa* of Canu and Bassler (1923, Pl. 35, fig. 9).

Another problem which came to light during the study of *H. bougainvillei* is one of a significant and peculiar regenerative condition. Marcus (1938, p. 119) reaffirmed that *H. hyalina* has male, female and asexual zooids. *Hippothoa bougainvillei* does likewise (fig. 4). However, *H. bougainvillei* exhibited another most interesting condition (fig. 3, 6), namely, of a few zooids which had two orifices set one within the other, the inner one a male, the outer one an asexual orifice, indicating that that particular zoid had served at one time as a male and at another time as an asexual zoid. Which condition came first could not be determined from the small number of such "double-duty" zooids (three) found in the collection. Although regeneration of a new polypide inside a zoecium is a well-known fact in the bryozoa, to my knowledge the present peculiar protandrous condition is singular, and is worthy of further experimental investigation in the only easily available closely related species, *H. hyalina*, by any interested worker.

SPECIES DISCUSSION

Hippothoa bougainvillei (d'Orbigny) 1839

(Figures 1-9, 11, 14, 16, 18, 22)

Synonymy and reported localities:—

1839. *Escharina bougainvillei*. d'Orbigny, p. 12, Pl. IV, Figs. 9-12; from the Falkland Islands.
1876. *Lepralia hyalina* var. *bougainvillei*. Busk, p. 117; Kerguelen Island.
1876. *Lepralia hyalina* var. *H* (unnamed till 1879). Busk, p. 117; Kerguelen Island.
1879. *Lepralia hyalina* var. *muricata* (see var. *H* above) and also var. *bougainvillei*. Busk, p. 197; Figs. 10, 11.
1880. *Schizoporella hyalina* var. from Santa Cruz. Hincks, p. 274, Pl. 45, Fig. 3.
1884. *Chorizopora hyalina* var. *bougainvillei*. Busk, p. 184, Pl. 22, Fig. 4; Kerguelen Island, Tristan da Cunha and other stations, to 90 fathoms' depth.
1909. *Schizoporella hyalina*. Calvet, pp. 25-26; Bay of Flandres, Schollaert, Port Charcot, Booth Wandel and Wyncke Islands, from 0 to 40 meters.
1952. *Hippothoa hyalina* (part at least?). Vigeland, p. 8, Pl. 2, Fig. 1; from a number of stations between South Georgia and Peter I Island, around the Palmer Peninsula (southern latitudes), Antarctic and sub-Antarctic.

Diagnosis:—Encrusting, hyaline to porcellaneous. Zooecial front non-porous, transversely rugose usually, sometimes carinated and umbonated. Carina may develop a sub-oral and up to 4 additional peaks or umbones, blunt or sharpened to a point. Autozooecial and male zoid orifices rounded, with a U-shaped sinus proximally, but male orifice is much smaller. Condyles bicusped. Female zoid orifice hemispherical, with V-shaped sinus in the otherwise straight proximal border. Ovicell globose, salient; surface texture variable from nearly smooth to rugose to prickly and lumpy, and from almost no pores to a small number. The prickles or "spines" are usually worn down to form irregular, elevated craters or rough-edged pores. No avicularia. Short, broad, lateral interzooecial connectives sometimes quite noticeable.

EXPLANATION OF PLATE I

All figures on this plate are of *Hippothoa bougainvillei* and were made with the aid of a camera lucida.

FIGURE 1. Two heavily calcified zooids, the left one, with ovicell female, the right one a normal autozoid. Wall heavily rugose. Colony grew on a thick hydroid stalk from Sta. 162. Drawn to the 0.1 mm. scale above.

FIGURE 2. Polypide (tentacles, digestive tract, musculature) inside a lightly calcified autozoid. The loop on the extreme left is part of the calcification of the basal wall. At lower left is an interzooecial bridge or connective. Compare with figure 5. Drawn to the 0.1 mm. scale below.

FIGURE 3. Two zooids of medium calcification, wall lightly rugose. The top zoid is female, ovicelliferous. The bigger zoid below is apparently protandrous and very unusual in having two orifices, one within the other, the inner one male, the outer autozooecial. Shown in greater detail in figure 6. Colony grew on an algal fragment, Sta. 104. Drawn to the figure 7 scale.

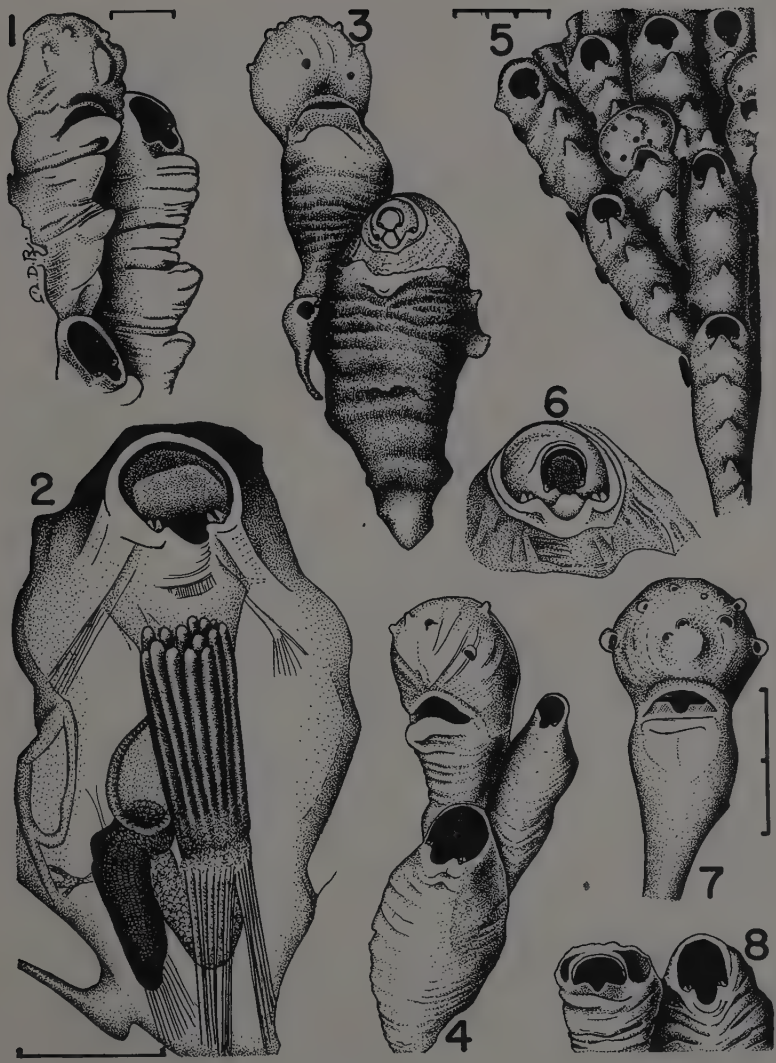
FIGURE 4. Three zooids, the top left a female, the small right a male and the bottom one an autozoid. Surface only lightly rugose. Drawn to the figure 7 scale.

FIGURE 5. Nine zooids with spinous rather than rugose fronts and interzooecial connectives separated by spaces (blackened here). The top row third zoid from left has four peaks or umbones, the bottom two above the orifice of the zoid below. From a Sta. 163 lava rock colony. Drawn to the 0.3 mm. scale above.

FIGURE 6. The double orifice of the protandric zoid of figure 3. Inner darkened male orifice has operculum in place. Male zoid umbo is in the sinus of the autozoid orifice. Bicusped teeth are on each side of the sinus in both orifices. Space between the two orifices is only lightly calcified. Drawn to the figure 2 scale.

FIGURE 7. A young oöciozoid from the same colony as figure 3, with an ovicell that shows the thin blisters or processes (some broken through to form pores). An umbo is forming just below the orifice. Zooecial front quite smooth. Drawn to the 0.2 mm. scale at right.

FIGURE 8. Two zooids, female at left and autozoid at right. Orifices blackened. The ovicell is just beginning to form around the base of the female orifice. Drawn to the figure 7 scale.



Measurements:—Given below are minimum, maximum and the average of a number of readings (usually 10), in millimeters. L is for length, W for width.

0.533—0.893 (0.701)	L	ordinary autozoöecia
0.216—0.331 (0.263)	W	" "
0.221—0.475 (0.384)	L	male zoöecia
0.130—0.158 (0.144)	W	" "
0.274—0.619 (0.456)	L	female zoöecia, exclusive of ovicell
0.158—0.288 (0.197)	W	" " " " "
0.202—0.259 (0.223)	L	ovicell
0.187—0.288 (0.226)	W	"
0.227—0.284 (0.265)	L	ancestrula
0.149—0.205 (0.179)	W	"
0.086—0.130 (0.110)	L	autozoöecial orifice, including sinus
0.094—0.115 (0.104)	W	" "
0.057—0.085 (0.068)	L	female orifice, including sinus
0.078—0.099 (0.087)	W	" "
0.035—0.060 (0.048)	L	male orifice, including sinus
0.035—0.060 (0.047)	W	" "
0.064—0.074 (0.066)	L	ancestrula orifice, including sinus
0.057—0.067 (0.063)	W	" "

The measurements of zoöecia were made on flat, uncrowded individuals. In occasional colonies where the space for growth is limited zooids may pile up in celleporid fashion, so that zooids are nearly upright. Sometimes a colony forms around a single sponge spicule.

Zoarium:—Colonies generally small, encrusting, unilaminar. The extreme forms may have a jagged craggy surface (fig. 1, 5). The least extreme form may be very hyaline and gently ripply (fig. 4, 7).

EXPLANATION OF PLATE II

All figures are done with the aid of a camera lucida.

FIGURE 9. An *H. bougainvillei* autozoid orifice with bicusped condyles to each side of sinus. Drawn to the 0.1 mm. scale at left.

FIGURE 10. An *H. distans* autozoid orifice with operculum in place. Unicuspated condyles visible. Sinus wide. Drawn to the figure 9 scale.

FIGURE 11. *H. bougainvillei* oöeciozoid, with ovicell forming about the orifice. Strong plate-like umbo below orifice. Drawn to the figure 16 scale.

FIGURE 12. Autozoid and female zoid (ovicelled) of *H. distans*. Drawn to the figure 16 scale.

FIGURE 13. *H. distans* autozoid with polypide (tentacles, gut, muscles) inside. Drawn to the figure 16 scale.

FIGURE 14. *H. bougainvillei* autozoid operculum. Chitinous rim in black, sclerites at sides, close to chitinous rim. Drawn to the figure 9 scale.

FIGURE 15. *H. hyalina* oöeciozoid operculum from Woods Hole, Mass. material. The two sclerites are a bit farther from the edge than those of *H. bougainvillei*. Drawn to the figure 9 scale.

FIGURE 16. Well calcified ovicell of *H. bougainvillei* with the blister or spinous processes broken off to form pores. From Sta. 163 rock. Drawn to the 0.1 mm. scale above.

FIGURE 17. *H. hyalina* oöeciozoid operculum from Woods Hole material. Sclerites at sides. Drawn to the figure 9 scale.

FIGURE 18. *H. bougainvillei* male zoid orifice, with the bicusped condyles, drawn to the figure 9 scale.

FIGURE 19. *H. distans* oöeciozoid operculum. Sclerites at sides. Drawn to the figure 9 scale.

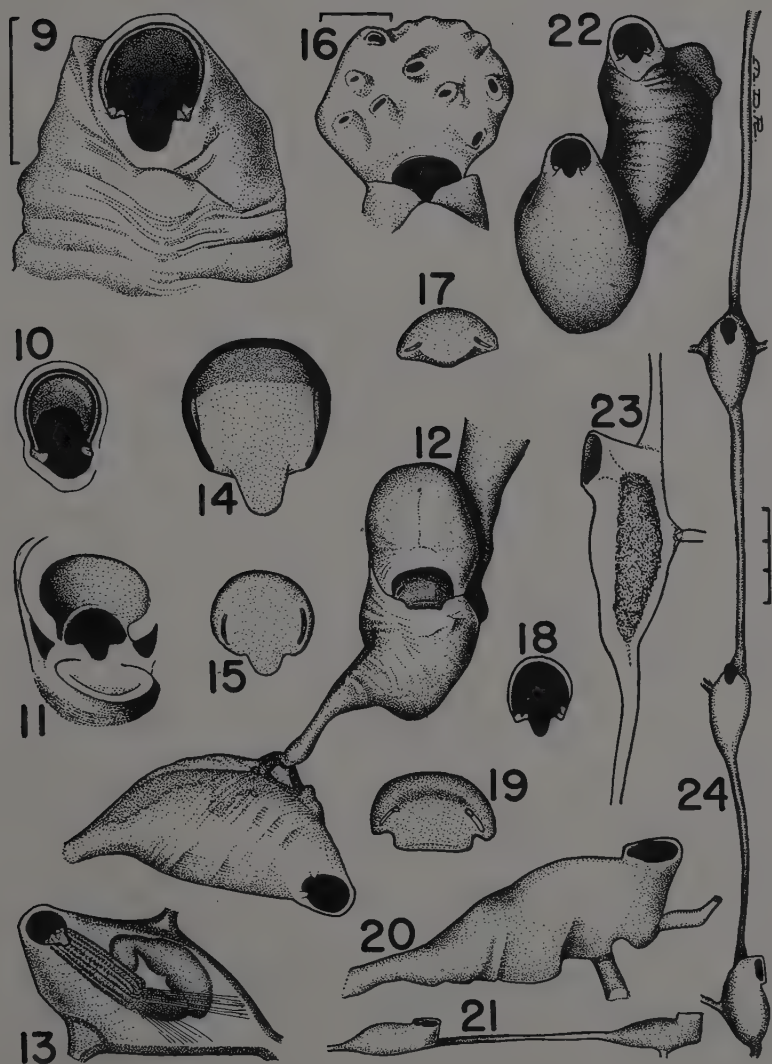
FIGURE 20. *H. distans* autozoid with very irregular sides and base. Two other zoid stalks arise from it. Drawn to the figure 16 scale.

FIGURE 21. Typical *H. distans* autozooids in profile, one with side branch. Plane of orifice parallel to plane of base. Drawn to the figure 16 scale.

FIGURE 22. Smooth oval ancestrula and a lightly rugose autozoid of *H. bougainvillei*. Drawn to the figure 16 scale.

FIGURE 23. *H. distans* zoid in profile, with tentacle sheath and polypide remains. Base more typical than figure 20. Drawn to the figure 16 scale.

FIGURE 24. Unusually long *H. distans* zooids. Drawn to the 0.3 mm. scale at right.



Zooecia:—Three easily recognizable kinds of zooecia (fig. 4), female, male and autozooids, are present in a colony. A protandrous transformation may possibly occur in at least two of these zoid types. Three zooids, with double orifices (a male orifice inside an autozoid orifice, pictured in fig. 3 and 6) were seen, indicating that those particular zooids had functioned either as male or as ordinary (non-sexual?) zooids, at different times. Unfortunately it was impossible to determine which condition was the preliminary one.

The zooecial surface is transversely corrugated. A keel may develop in some zooids. A suboral umbo is generally present. In female zooids it is a distinct flap partly concealing the orifice (fig. 1, 3, 11). The few other hollow umbones may be slight, mound-like or may rise to sharp peaks, along the median longitudinal frontal axis. Occasional zooids develop a pair of umbones near the two lower proximal corners, just above the orifice of the next proximal zoid (fig. 5).

The back wall is incomplete. Broad interzooecial connections exist (fig. 2, 5) between which are slit-like spaces or fenestrae. There seems to be no set pattern or consistency in their appearance.

Tentacle number was about 14 (fig. 2).

Ancestrula:—The ancestrula is like that of *H. hyalina* (see Barrois' 1877, Pl. 9, Figs. 9-16 of *Mollia hyalina*). It is oval, generally not corrugated nor keeled (fig. 22). Its orifice resembles in shape those of male and ordinary zooids.

If one disregards the sinus it can be said that the female orifice is hemispherical (fig. 8, 11) while the male and autozoid orifices are rounded to oval. The sinus is V-shaped in females, U-shaped in the others. The sinus is set off by two sharp corners from the rest of the orifice. In an incised location further to each side of the sinus is a bicusped condyle which seems to be a significant difference between *H. bougainvillei* and *H. hyalina*. The latter has unicusped condyles.

Ovicells:—The salient, globose to peaked ovicells are quite variable as to decoration. Their surface may assume any of the following conditions: nearly smooth, with a few blister-like pores; corrugated (fig. 4); umbonated (fig. 5, 7); irregular, lumpy or misshapen (fig. 16); burry or prickly, with prickles broken off or worn down to slightly elevated craters (fig. 16). The prickly ones were the least abundant and occurred mostly on a lava rock from Sta. 163. Busk at first (1879, p. 197, Fig. 11) called the prickly type var. *muricata* but later (1884, Pl. 22, Fig. 4) pictured the same type as var. *bougainvillei*, apparently relegating *muricata* to the synonymy of *bougainvillei*.

Ovicell porosity is varied. Some ovicells have almost no pores, others have a small number. The pores are irregular in size, shape and distribution. They appear as little blisters or prickles on the ovicell surface. They are generally not as large nor as close together as those of *H. hyalina*.

Avicularia and stolons:—Absent.

Distribution and ecology:—Very small amounts of *H. bougainvillei* were collected from the following Antarctic localities by Comdr. D. C. Nutt during the U. S. Navy's 1947-48 Antarctic Expedition: *a*, on Jan. 29, 1948, at 58 fathoms, from Sta. 104, off Cape Royds, Ross Island in the Ross Sea Area; *b*, on Feb. 15, 1948, at 30 fathoms, from Peter I Island Area Stations 149, 162, 163; *c*, from the Marguerite Bay Area on Feb. 20, 1948, at 35 fathoms from Stations 189, 190, 193, 194, —on Feb. 22, 1948, at 40 fathoms from Stations 225, 226, 229, 230, 233, 234, 236, 238, 240 and from debris entangled on a starfish from Sta. 243 (Mr. Layton collector). The species was also found in Case 1 and on pebble No. 2, collection data lacking. Material from most of these stations is deposited in the U.S. National Museum. The colonies grew on various substances: algae, pebbles, sponge spicules, hydroid stems and assorted bryozoans. Some of the latter are: *Camptoplites latus* (Kluge) 1914 and *Camptoplites retiformis* (Kluge) 1914 of Sta. 230; *Carbasea tenuis* (Kluge) 1914 and *Flustra flagellata* Waters 1904 of Sta. 226; *Himantozoum antarcticum* (Calvet) 1901 of Stations 149, 226; *Notoplites drygalskii* (Kluge) 1914 and *Escharoides bubeccata* (Rogick, 1955, p. 442), of Sta. 104.

The frontal surface of the *bougainvillei* colonies was usually very clean, not overgrown with other species. However, some colonies from a lava rock from Sta. 163 were partly overgrown by a colony of *Escharoides tridens* (Calvet) 1909. A few embryos were present in the

ovicells growing on a hydroid stalk from Sta. 162 (Feb. 15). A number of ancestrulae with young as well as advanced colonies came from Sta. 226. Most of the material consisted of empty colonies or colonies which had few living polypides at the time of collection.

Hippothoa distans MacGillivray 1869

(Figures 10, 12, 13, 19, 20, 21, 23, 24)

Synonymy and reported localities:

- 1869. *Hippothoa distans*. MacGillivray, p. 130; Australia.
- 1870. *Hippothoa flagellum*. Manzoni, p. 328, Pl. 1, Fig. 5; Pliocene fossil from Italy; and live from the Mediterranean, (Manzoni, 1871, according to Hincks, 1880, p. 293).
- 1880. *Hippothoa flagellum*. Hincks, p. 293, Pl. 44, Figs. 5-7; Cornwall, Guernsey, South Devon, Shetland, etc.
- 1884. *Hippothoa flagellum*. Busk, p. 4, Pl. 33, Fig. 7; off Heard Island, 75 fathoms.
- 1889. *Hippothoa distans*. MacGillivray, pp. 321-322, Pl. 187, Figs. 10-13. (Illustrations of the species whose description was made in 1869.)
- 1938. *Hippothoa distans*. Marcus, pp. 212-213. Excellent for synonymy and distribution.
- 1952. *Hippothoa distans*. Brown, pp. 203-204. More synonymy and distribution records.
- 1952. *Hippothoa flagellum*. Osburn, Pl. 30, Figs. 7-8, p. 278. Pacific coast of Mexico and South America.

Diagnosis:—Colony encrusting, diffuse; branching open, lateral and longitudinal. Zooecia small, hyaline, non-porous, greatly prolonged and narrowed proximally. Plane of autozoecial orifice parallel with the attached dorsal zooecial surface. Ooeciozooids smaller, their orifice wide, with very shallow broad sinus. Ovicells non-porous, unadorned, mitriform. Autozoid orifice narrow, ovate, with two unicusped condyles limiting the sinus.

Measurements:—H is for height, D for diameter.

0.326—0.531 (0.404) L autozoid "body" exclusive of the proximal prolongation or "stolon"

0.149—0.234 (0.183) W autozoid "body" or swollen part

0.113—0.142 (0.128) H autozoid, from substrate to plane of orifice

0.326 (only one) L female zoid, exclusive of ovicell

0.453 L female zoid, including ovicell

0.148—2.035 (0.958) L of "stolon" or proximal extension of zoid

0.021—0.032 (0.026) D of "stolon" or zoid extension

0.184 L ovicell

0.149 W "

0.064—0.078 (0.072) L autozoecial orifice, including sinus

0.044—0.071 (0.059) W " "

0.060 L female zoid orifice, including sinus

0.081 W " " "

0.053 W female zoid orifice sinus

0.011 H " " " "

0.028 W. autozoid sinus

Priority problem:—The question of the correct name, date and author still persists. The reason for it is that MacGillivray's original description (presented during the Nov. 26, 1868 session of the Royal Society of Victoria and published in Jan. 1869) was unaccompanied by illustrations. For some reason he was in a great hurry to publish descriptions of 48 new species of bryozoa without accompanying illustrations. He stated that the illustrations were to appear in the forthcoming or projected "Memoirs of the Museum" under McCoy's direction. Forty-four of these 48 species were eventually illustrated in McCoy's "Prodromus" which appeared from 1878 to 1890. *Hippothoa distans* appeared in 1889. In the meantime, Manzoni in 1870 described and figured *H. flagellum*, an Italian fossil, which to all appearances seems to be identical with *H. distans*. Some workers have used Manzoni's name in preference to MacGillivray's, but in view of all the circumstances MacGillivray's name should have priority.

Zoarium:—Colony encrusting; inconspicuous because of the small, widely spaced, pyri-

form zooecia. Zooecial branches sprout from the sides and distal end of a zoid (fig. 20, 24). The zoids are drawn out to a fine long tube proximally (fig. 24). Brown (1952) reported these slender processes to be up to 0.53 mm. long. The Antarctic specimens had a greater range, 0.148-2.035 mm.

Zooecia:—The fragile, brittle, non-porous, transparent front wall varies from smooth to faintly rugose transversely (figs. 12, 20, 21). In side view the zooecial orifice is steeply elevated, its top parallel with the substratum (fig. 21, 23). It differs from *H. bougainvillei* whose orifice is oblique with respect to the substratum (fig. 1). No male zoids were seen. Whether they exist is unknown.

Avicularia:—Absent.

Orifice:—The autozooecial orifice is similar to that of *H. hyalina*, having unicusped condyles (fig. 10). The oeciozoid orifice has a shallow but broad sinus, intermediate between the *bougainvillei* and *hyalina* conditions (fig. 11, 12, 17, 19).

Ovicells:—Only an empty, smooth, non-porous one seen (fig. 12).

Distribution and ecology:—This species is one of surprisingly wide distribution. Previous workers have reported it from fossil deposits of Japan, New Zealand and Italy (Pliocene) and as Recent species from Australia, the Azores, Brazil, Cape Verde Islands, Europe an seas, Indian Ocean, Malaya, New Zealand, Pacific Coast of North and South America, Philippines, the Tortugas and other localities. Waters (1904, p. 55) reported it from several Antarctic stations from depths of 480 to 569 meters. The U.S.N. specimens came from the following Antarctic stations: 104 and 190. Station 104 was farther south (about 77°30'S. Lat. and 166°E. Long.) than those of Waters (70°23'S. Lat., 82°47'W. Long.; and 70°15'S. Lat., 84°06'W. Long.) but considerably shallower (58 fathoms).

Most of the present specimens occurred on sponge spicules, hydroid stems, alcyonarian twigs and some on other bryozoa as *Clithriellum inclusum* and a Cribriulinid species, from Sta. 104. A smaller number occurred in the Sta. 190 material.

SUMMARY

1. Two living species, *Hippothoa bougainvillei* and *H. distans*, are reported from new Antarctic localities. *Hippothoa distans* is cosmopolitan, world-wide in distribution while *H. bougainvillei* is found only in the lower half of the southern hemisphere (Antarctic and sub-Antarctic).

2. *Hippothoa distans* is a distinct species but *H. bougainvillei* is likely to be confused with the cosmopolitan *H. hyalina*, hence its variations have been given in detail.

3. Possible problems for investigation are suggested, as protandry.

4. The question of the priority of *distans* over *flagellum* is further clarified.

5. A number of other bryozoa belonging to the genera *Camptoplites*, *Carbasea*, *Flustra*, *Himantozoum* and *Notoplites* are incidentally reported from new Antarctic localities.

LITERATURE CITED

- Barrois, J. 1877. Recherches sur l'embryol. des Bryoz. 305 pp., Paris.
 Brown, D. A. 1952. The Tertiary Cheilostomatous Polyzoa of New Zealand. Brit. Mus. Nat. Hist., 405 pp., London.
 Busk, G. 1876. Descr. of some new spp. . . from Kerguelen's Island. Ann. Mag. Nat. Hist. (4)17: 116-118.
 ———. 1879. Polyzoa, in An Account of . . . collections made in Kerguelen's Land . . . Philos. Trans. Roy. Soc. London. 168(extra vol.): 193-199.
 ———. 1884. Part I. Cheilostomata. Rept. Sci. Res. H.M.S. Challenger, 1873-76, Zool. 10(30): 1-216.
 Calvet, L. 1909. Bryozoaires. Exped. Antarct. Franç. 1903-05, Charcot. 50 pp., Paris.
 Canu, F., and R. S. Bassler. 1923. North Amer. Later Tertiary and Quaternary Bryozoa. Bull. 125, Smithsonian Inst., U. S. N. M., 291 pp., Washington.
 d'Orbigny, A. 1839. Voyage dans l'Amerique-Meridionale, V. Part IV. Zoophytes. 28 pp., Paris.

- Hincks, T. 1880. A history of British Marine Polyzoa. 2 vols. London. (Vol. 1, 601 pp., vol. 2, 83 pl.)
- Kluge, H. 1914. Die Bryozoen der Deutschen Südpolar-Exped., 1901-03. Deutsche Südpolar Exped., XV, Zool. 7: 599-678.
- MacGillivray, P. H. 1869. Descr. of some new Genera and Spp. of Austral. Polyzoa. Trans. Proc. Roy. Soc. Victoria. 9: 126-148.
- . 1889. Polyzoa, in McCoy's Prodrum of the Zool. of Victoria, Decade XIX, 2: 307-323.
- Manzoni, A. 1870. Bryozoi fossili Italiani. Sitzungsber. Math.-Naturw. Classe Kaiser. Akad. Wissensch., LXI Band, 1 Abt., Heft 1-V: 323-349.
- Marcus, E. 1938. Bryoz. marinh. brasil II. Bol. Faculd. Philos., Sci. e Letr., IV, Zool. 2: 1-196.
- Osburn, R. C. 1952. Bryoz. Pacific Coast, Part 2. Allan Hancock Exped., 14: 271-611.
- Rogick, M. D. 1955. Studies on marine Bryozoa. VI. Antarctic *Escharoides*. Biol. Bull. 109: 437-452.
- Vigeland, I. 1952. Antarctic Bryozoa. Sci. Res. Norweg. Antarct. Exped. 1927-28. 34: 1-16.
- Waters, A. W. 1904. Bryozoa. Exped. Antarct. Belge. Result. Voy. Belgica en 1897-99. Zool., 114 pp.

The Luminescence of Biological Systems. Frank H. Johnson, Editor. American Association for the Advancement of Science, Washington, D. C. 1955. xiv+452 pp. \$7.00 (\$6.00 to AAAS members).

Any biologist who can recall the excitement and wonder of his first childish experience with the fascinating flashing light of the firefly can look forward to an equally exciting experience in following the development of the quantitative investigation of this and other bioluminescent phenomena.

This book consists of the seventeen papers presented by the members of the Conference on "The Luminescence of Biological Systems" held at Asilomar, California, 1954. The Conference was planned by the Committee on Photobiology of the National Academy of Sciences—National Research Council and supported by the National Science Foundation.

The first paper by E. Newton Harvey summarizes the present knowledge of bioluminescence in the plant and animal kingdoms. Most biologists will find the paper on the kinetics of chemiluminescence rather heavy going but they should take comfort from the fact that the problem is attracting such competent assistance. The two papers on the physiological control of luminescence are of unusual interest and point up nicely a large area where much further research is needed.

J. E. VARNER.

The Preservation of Natural History Specimens. Part I. Invertebrates. R. Wagstaffe and J. H. Fidler. Philosophical Library, Riverside Press, Edinburgh, England. 1955. xiii+205 pp. 139 figs. \$10.00.

New books on biological techniques are usually very helpful, especially if they restrict the subject matter to a limited area. The new book entitled "The Preservation of Natural History Specimens" by Wagstaffe and Fidler does this very thing. It presents various techniques used in killing, cleaning, staining, preserving, mounting, etc. of all phyla among the invertebrates, with particular emphasis on those found in Great Britain.

The first portion of the book, pages 1 to 144, presents preservation techniques associated with some to many representatives of all invertebrate phyla. Techniques associated with arthropoda occupy more than 50 per cent of the space, especially insects which cover some 70 pages. Some of the techniques are different from those practiced in the United States among investigators or curators. It is very probable that zoologists and entomologists will profit by the information presented.

The second portion of the book, pages 147 to 200, entitled Appendix I to V gives detailed facts on apparatus and instruments, reagents, labels and labelling, storage and microscopy.

The book is well illustrated throughout with many excellent line drawings. These are very helpful in clarifying given techniques.

Since the reviewer is an entomologist he is particularly interested in the section on Arthropoda. He has learned from reading this portion several methods which he will try out in the near future. It should also be said that there are various new and modified techniques that entomologists in North America are using today which have been omitted in this volume. This is not too serious for the reviewer has prepared publications on techniques and he knows how difficult it is to be up-to-date on all techniques.

All told this book should be very useful especially for investigators, teachers and curators.

ALVAH PETERSON.

Now ready—

The New 1956 Turtox Domestic and Foreign Want Lists

These lists describe hundreds of plant and animal specimens that we wish to purchase and state the price we offer for each. If you have biological material for sale, or if you are interested in collecting for us, write for the 1956 Want List.

If you live in the United States or Canada, ask for the 1956 Turtox Domestic Want List. If you live in any other country, write to us via air mail and ask for the 1956 Turtox Foreign Want List.

GENERAL BIOLOGICAL SUPPLY HOUSE, Inc.

8200 So. Hayne Ave.
CHICAGO 20, ILLINOIS

ARLINGTON LABORATORIES

RESEARCH AND TESTING
in Clinical Biochemistry, Bacteriology, Serology, and Immunohematology. Small animal testing.

Let us do the laboratory
work for your research
project.

COMPLETE CLINICAL LAB-
ORATORY FACILITIES. PRO-
TEIN-BOUND IODINE DETER-
MINATIONS. Blood Group Sen-
sitzation Studies.

For information write
P. O. Box 5142
Columbus 12, Ohio

Fishing with Natural Insects

by ALVAH PETERSON,
Professor of Entomology,
The Ohio State University,
Columbus 10, Ohio

Chiefly a Handbook of Insects for Bait Use
Non-technical and Extensively Illustrated

SOME TOPICS DISCUSSED

Some essential facts about insects.
Life and habits of more than sixty kinds of bait insects
with photographs.
Collecting, trapping, rearing, maintaining, and pre-
serving bait insects with illustrations.
A bait calendar.
Insects for winter and ice fishing.
Some lures that resemble insects.
Location, natural food and bait insects for twenty-five
common pan and game fishes.

HOW TO PURCHASE

Distribution is handled by the Author.
Place orders with the Author or a Book
Dealer. If you live in the State of Ohio
all taxable orders must come through
a book dealer.

If money comes with order postage is pre-
paid in U.S.A. Book dealers and Public
Libraries receive a discount. Price \$6.00
"An excellent book for any fisherman,
naturalist or Public library."

Order Now
from
Author

Cloth-bound, 6 x 9,
letter press on
enameled paper with
64 plates of figures.

THE SPAHR & GLENN CO.
FIFTY EAST BROAD STREET, COLUMBUS 15, OHIO